CONSERVATION OF THE QUEEN CHARLOTTE GOSHAWK IN SOUTHEAST ALASKA

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A PROPOSED STRATEGY FOR MAINTAINING WELL-DISTRIBUTED, VIABLE POPULATIONS OF WILDLIFE ASSOCIATED WITH OLD-GROWTH FORESTS IN SOUTHEAST ALASKA

by

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The goshawk appendix in Suring et al. (1993), by D. C. Crocker-Bedford, was completed in April 1992. The following revision of 5 May, 1994, includes a summary of 1992 and 1993 field research on the Queen Charlotte goshawk (ADF&G 1993a, 1993b, 1994), as well as many additional literature citations. The following document is also responsive to the major peer review completed March 1994 (Kiester and Eckhardt 1994).

CONSERVATION OF THE QUEEN CHARLOTTE GOSHAWK IN SOUTHEAST ALASKA

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SUMMARY

The Queen Charlotte goshawk (*Accipiter gentilis laingi*) is endemic to southeast Alaska and coastal British Columbia. Owing to its restricted distribution and low natural densities, its population was probably never great. Timber harvesting appears to have reduced habitat capability for the Queen Charlotte goshawk. The current population in southeast Alaska is roughly estimated at 100-200 pairs. Adults of other subspecies of northern goshawks usually have summer home ranges between 1,400 ac and 9,300 ac. In northeastern southeast Alaska, near Juneau, Queen Charlotte goshawks appear to have summer home ranges of similar sizes, but in southern southeast Alaska summer home ranges known by 1993 for 3 breeding pairs were an order of magnitude larger: 36,900 ac (81% land), 101,600 ac (50% land), and 288,700 ac (68% land) (ADF&G 1993a, 1994).

Analyses of habitat use have shown similar results throughout the geographical range of the northern goshawk in the United States. Home ranges include stands of large trees for nesting, as well as for greater abundance of some prey. The higher canopy provided by large trees, along with sparser than normal shrubs and small trees, appears to facilitate goshawk flight and prey capture. Closed canopies appear to provide preferred microclimate in the nesting stand, increased productivity of some important prey species, and reduced competition and predation by open-forest raptors. A literature review indicated that goshawk densities tend to decrease with amount of timber harvest, and that goshawks may sometimes be impacted by forest fragmentation. In southeast Alaska 92% of the relocations on radio-tagged goshawks were in old-growth forests having over 8 mbf/ac. Old-growth having over 20 mbf/ac was most preferred.

Habitat Conservation Areas, Primitive Recreation Areas, Wilderness Areas, and other large protected areas, provide important habitat for Queen Charlotte goshawks without the necessity for expensive and often inconclusive nest surveys, and without speculative analyses for home range specific management plans. Still, because the population is so low and may be declining, an effort should also be made to maintain sufficient habitat within all suitable home ranges which are outside of the large protected areas. Recommendations are made for nesting surveys and habitat management of individual home ranges. An alternative recommendation would reduce harvesting of old-growth to 5% of the suitable and available timber base of an assessment area during any one decade.

DISTRIBUTION AND POPULATION STATUS

Three subspecies of northern goshawks breed in North America (Johnsgard 1990). A. g. atricapillus is widely distributed over most of the forested regions of the United States and Canada. It is the gray form with bluish tint shown in most North American field guides. The Apache goshawk (A. g. apache) is larger and has heavier feet, and is found only in northwestern Mexico and the southern portions of Arizona and New Mexico (Brown and Amadon 1968).

The Queen Charlotte goshawk (A. g. laingi) is darker than most A. g. atricapillus (Taverner 1940). It is often very blackish and is found only in southeast Alaska and coastal British Columbia (Webster 1988). Beebe (1974:54) described the consistent features of A. g. laingi: Mature adults "have the black of the head extending to nearly the mid-point of the back before lightening" somewhat---often "to a dark, leaden grey;" the "close barring of the underside is darker and courser than that of continental birds, with the shaftline marks wider and black, not grey;" and "immatures are similarly much darker, the only real white anywhere being the eyebrow line, nape feathers, and undertail plumes." Specimens from Vancouver Island, British Columbia, as well as Baranof Island and Taku Inlet, northern southeast Alaska, "are not quite as black as those from the Queen Charlotte Islands", which perhaps indicates the edges of the subspecies range (Webster 1988).

Beebe (1974:54) believed that the birds of Vancouver Island were a distinct, not yet described, subspecies. He stated they were "almost as dark as A. g. laingi but fully one-third smaller" by weight than goshawks from the Queen Charlotte islands. Johnson (1989) found no statistically significant difference in wing lengths between the populations of Vancouver Island and the Queen Charlotte islands, though his sample size was small. Conducting their own measurements on all specimens, both Johnson (1989) and Whaley and White (1993) found that laingi goshawks had significantly shorter wings than did goshawks from the adjacent mainland, and that subspecific status was warranted. Whaley and White (1993) determined that A. g. laingi was the smallest goshawk in North America.

Wingchord measurements from breeding goshawks in southeast Alaska (ADF&G 1994) averaged longer than the A. g. laingi museum specimens measured by Whaley and White (1993); however, the ADF&G (1994) measurements were from living birds, while the museum specimens measured by other authors may have shrunk when dried. The smallest wingchord measurements by ADF&G (1994) were from southern southeast Alaska and were within the range of A. g. laingi reported by Whaley and White (1993). Although the sample sizes were too small for statistical significance, the shorter measurements from south of 57 deg 30 min latitude (Angoon, Admiralty Island), as compared to those north of there (ADF&G 1994), implied different populations within southeast Alaska.

The breeding birds examined in 1992 and 1993 in southeast Alaska exhibited plumage characteristics which were largely similar to those described by Taverner (1940) and Beebe (1974) for the Queen Charlotte subspecies (ADF&G 1994). C. Flatten (ADF&G, pers. comm.) previously worked with goshawks on the Olympic Peninsula of Washington, where he also observed goshawks with plumage characteristics of the Queen Charlotte goshawk. He observed that rainforest characteristics on the Olympic Peninsula were similar to those in southeast Alaska, and probably present similar selective pressures. Goshawks on the Olympic Peninsula "are believed to be relatively isolated there" (Thomas et al. 1993:290).

C. Flatten (pers. comm.) and I suggest that the range of goshawks, which exhibit the morphological characteristics of the Queen Charlotte goshawk, extends along the Pacific Coast from northern southeast Alaska to western Washington. Slight size and slight plumage differences indicate that the subspecies may be separated into at least five populations: northern southeast Alaska, southern southeast Alaska, Queen Charlotte Islands, Vancouver Island, and Olympic Peninsula. Separate populations would be expected given the large bodies of sea between them, combined with the resident nature of the goshawks of southeast Alaska (ADF&G 1993a, 1994), the Queen Charlotte Islands (Beebe 1974), Vancouver Island (Beebe 1974), and the Pacific Northwest rainforest (Thomas et al. 1993, Whaley and White 1993). The amount of mixing between adjacent populations is unknown.

Between 1990 and 1994, population estimates for the Queen Charlotte goshawk have been repeatedly revised downward. In 1990 a habitat capability model (Crocker-Bedford 1990a) estimated the 1988 habitat capability at less than 800 pairs in southeast Alaska and less than 2,500 pairs for southeast Alaska and British Columbia combined. The model also estimated a decline in habitat capability of at least 30% in southeast Alaska and more than 50% within the subspecific range of the Queen Charlotte goshawk. Later, C. Iverson (USDA Forest Service, unpubl. rep. Nov. 1990) suggested that the habitat capability estimates were too high and the projected declines in habitat capability were too small: The 1990 habitat capability model had not accounted for the perceived higher habitat value of higher volume old-growth forests for prey production and accessibility (goshawk flight space), nor did the model consider the fact that past logging had concentrated in stands of higher volume timber. Recent data (ADF&G 1993a, 1994) have demonstrated that goshawks in southeast Alaska prefer old-growth forest habitat having over 20 thousand board feet per acre (mbf/ac) more than that of 8-20 mbf/ac, and that home ranges of pairs of Queen Charlotte goshawks are often many times larger than the assumptions of the Crocker-Bedford (1990a) model. Furthermore, much of the habitat capability which Crocker-Bedford (1990a) calculated for the Queen Charlotte goshawk in British Columbia was from coastal mainland forest, but R. W. Campbell (author Birds of British Columbia, pers. comm. 3 May 1994) found that most birds there are <u>A. g.</u> atricapillus and that Queen Charlotte goshawks are mostly restricted to islands.

In 1991 the Supplementary DEIS for the Tongass Land Management Plan calculated a potential habitat capability (usually higher than actual population) of 314-381 pairs for southeast Alaska (USDA Forest Service 1991a:3-533). By 1992 the professional estimates of several biologists---based primarily on the paucity of goshawk sightings relative to time in the field by biologists and birders---were that the actual population of goshawks in southeast Alaska was under 500 pairs and might possibly be lower than 200 pairs (Crocker-Bedford 1993). By 1994 new information on nesting home range size and habitat use, when compared to habitat availability, allowed the principle investigator of goshawks in southeast Alaska to roughly estimate the total goshawk population of southeast Alaska at 120 pairs (K. Titus, ADF&G, pers. comm. 16 Feb. 1994).

Given all the above, I estimate that the true population in southeast Alaska is 100-200 pairs. However, Forsman (1994) was correct in stating that all we know for sure about the population of southeast Alaska is that goshawks "are relatively rare, and that they are probably declining as a result of habitat loss." In British Columbia, Queen Charlotte goshawks are mostly restricted to coastal islands---few exist on the coastal mainland---and they are rare even on the islands (R. W. Campbell pers. comm. 3 May 1994).

The USDI Fish and Wildlife Service (1992) has designated the northern goshawk (including all three subspecies) as a Category 2 Candidate Species for Threatened or Endangered Status in the United States.

> "Category 2 includes those taxa for which there is some evidence of vulnerability, but for which there are not enough data to support a listing proposal at this time. Elevation to Category 2 does not mandate initiation of a status review. However, because of the level of concern for the goshawk, the [USDI Fish and Wildlife] Service" has initiated a "status review (50 CFR 424.15) to better understand trends in population size and stability and loss or modification of habitat." (Ibid.:545).

As of February, 1992, goshawks were on the Sensitive Species lists of three Forest Service Regions: Southwest, Intermountain, and Pacific Southwest. In Alaska goshawks were under consideration for Forest Service Sensitive Species status since 1986 (Sidle and Suring 1986). In January 1994 the Queen Charlotte goshawk was added to the Sensitive Species list of the Alaska Regional Forester.

The Alaska Natural Heritage Program ranked the Queen Charlotte goshawk as T1/T2 (West 1993). This means that the subspecies in its entirety is believed to be either "Critically imperiled globally" or "Imperiled globally." Individual populations of the subspecies would be at more risk than the subspecies in total. For example, goshawks in southern southeast Alaska appear to be very sparse and have exhibited extremely large home ranges (see sections on Home Range and Population Densities).

PATTERNS OF HABITAT USE

Food Habits

The hunting technique of goshawks has been described as "short-stay perched-hunting"---where nearly all attacks are launched straight from perches---by Kenward (1982), whose study areas were mixtures of woodlots and agriculture. Widen (1984) studied goshawk hunting behavior in a coniferous forest in south-central Sweden, and he concluded for coniferous forest: "Flying through the forest, flushing the prey by surprise, may be a more efficient hunting technique in this habitat" than striking from perches, though much hunting still occurred from perches.

In Sweden flights between hunting perches averaged 1.5 min and the distribution was skewed towards shorter periods so the median flight duration was 0.4 min (Widen 1984). In New Mexico flights of adult males averaged 2.3 min while those of adult females averaged 1.1 min, though both sexes exhibited a median flight duration of 0.5 min (Kennedy 1990). In Sweden time at perches averaged 8.6 min for males and 10.4 min for females, but the median time per perch was only 3 min for both sexes (Widen 1984). In New Mexico time at perches averaged 11.2 min for males and 12.7 min for females, but both sexes exhibited a median time per perch of 3.5 min (Kennedy 1990). Time per perch was much longer if a bird had already fed that day: 31 minute average, 7 minute median (Widen 1984).

Goshawks use relatively large prey. In northern Arizona from late incubation to fledging, mammals contributed 94% of the prey biomass: 26% cottontails (Sylvilagus spp.), 15% ground squirrels (Spermophilus lateralis), 10% rock squirrels (S. variegatus), 15% tassel-eared squirrels (Sciurus aberti), 6% red squirrels (Tamiasciurus hudsonicus), and 22% other mammals (Mannan and Boal 1993). The Arizona study showed a higher proportion of mammals than any other goshawk dietary study, in part because it used direct observations of nest returns rather than analysis of prey remains (Mannan and Boal 1993), but perhaps also owing to prey availability caused by forestry practices and proximity to more open habitat types (Pinus edulis and Atemesia tridentata). In New Mexico goshawks consumed nearly equal amounts of mammalian and avian prey during late summer, primarily northern flickers (Colaptes auratus), Steller's jays (Cyanocitta stelleri), American robins (Turdus migratorius), tassel-eared squirrels, red squirrels, and cottontails (Kennedy 1989, 1990). In Oregon during the nesting season, 65% of the prey biomass was mammalian, half from mammals larger than 450 g---grey squirrels (S. griseus), cottontails, and hares (Lepus spp.)---and half from mammals smaller than 450 g---especially ground squirrels (Spermophilus spp.), Douglas squirrels (T. douglasi), flying squirrels (Glaucomys sabrinus), chipmunks (Eutamias spp.), and woodrats (Neotoma spp.) (Reynolds and Meslow 1984). In Oregon 35% of the prey biomass was avian, half from birds larger than 200 g---mallards (Anus platyrhynchos), Cooper's hawks (A. cooperii), blue grouse (Dendragapus obscurus), ruffed grouse (Bonasa umbellus), mountain quail (Oreortyx pictus), great horned owls (Bubo virginianus), and pileated woodpeckers (Dryocopus pileatus)---and half from birds smaller than 200 g.---especially mourning doves (Zenaida macroura), northern flickers, Steller's jay, robins, and varied thrushes (Ixoreus naevius) (Reynolds and Meslow 1984). In California the primary prey brought to the nest were similar to those in Oregon, but mammals comprised 36% of the biomass and birds were 64% (Schnell 1958). Storer (1966) presented data from 223 goshawks collected from several States over all seasons, though especially during winter, which showed stomach contents having 55% mammals: especially cottontails, hares and red squirrels, but with some grey squirrels, ground squirrels, white-footed mice (Peromyscus spp.), voles (Microtus spp.) and redback voles (Clethrionomys spp.). The stomach contents were 45% birds: especially ruffed grouse, pheasants (Phasianus colchicus) and bobwhite quail (Colinus virginianus), but with some ptarmigan (Lagopus spp.), flickers, and thrushes (Hylocichla spp.---now Catharus spp.). Storer (1966) presented other information which showed that crows (Corvus spp.) can be common in the diet, and that passenger pigeons (Ectopistes migratorius) once were important in the East before their extinction.

Most of the mammalian prey listed above are rare or absent over most of southeast Alaska. The only ones that are found throughout most of southeast Alaska are flying squirrels, white-footed mice, voles and redbacked voles, but these are much smaller than optimal size for goshawks (Storer 1966, Reynolds and Meslow 1984). Red squirrels are absent from some islands, such as Prince of Wales (USDA Forest Service 1991a). Also, they are somewhat suboptimal in size (Storer 1966, Reynolds and Meslow 1984). The snowshoe hare (L. americanus) is the only mammal in southeast Alaska which is optimum size prey for goshawks (Ibid.), but it occurs in little of southeast Alaska---typically near the mouths of the major rivers from Canada (ADF&G 1978). Goshawks exhibit smaller home ranges and higher nesting densities in northeastern southeast Alaska near Juneau, where snowshoe hares were found in prey remains (ADF&G 1994). Snowshoe hare population cycles may cause goshawk breeding densities to vary by a factor of 7 or 8 in northern boreal forests (McGowan 1975, Doyle and Smith 1993).

Some of the avian prey listed above---Cooper's hawks, quail, pheasants and pileated woodpeckers---do not occur in southeast Alaska, while mourning doves are rare and northern flickers are uncommon (Armstrong 1990). Grouse may be denser in the general area of Juneau, where goshawks are denser than in southern southeast Alaska (C. Flatten, pers. comm.). Spruce grouse (Dendragapus canadensis) and blue grouse typically do not occur in the same locations in southeast Alaska (J. Gustafson, ADF&G, pers. comm.), and spruce grouse are rare in southeast Alaska (Armstrong 1990).

Goshawks consume many northwestern crows (Corvus caurinus) on the Queen Charlotte Islands, and mostly Steller's jays and varied thrushes on Vancouver Island (Beebe 1974, Johnsgard 1990). In southeast Alaska prey remains were collected at 15 goshawk nest sites (ADF&G 1994). Gross examination identified remains of Steller's jays from 100% of the nest sites, spruce or blue grouse from 73%, varied thrushes from 60%, red squirrels from 47%, woodpeckers including red-breasted sapsuckers (Sphyrapicus ruber) from 40%, sharp-shinned hawks (A. striatus) from 27%, marbled murrelets (Brachyramphus marmoratus) from 20%, yellowlegs (Tringa spp.) from 13%, and ptarmigan from 13%. The following species were identified at one nest (7%) each: waterfowl (Anatidae spp.), shorebird, northern saw-whet owl (Aegolius acadicus), belted kingfisher (Ceryle alcyon), northwestern crow, hermit thrush (Catharus guttatas), hare, and beetle (Coleaptera spp.). More species will probably be identified from the nests following a more thorough analysis of the collected prey remains (ADF&G 1994). I found remains of a nestling great blue heron (Ardea herodias) at one goshawk nest site.

Some of the above verified prey largely migrate out of southeast Alaska during winter: sharp-shinned hawk, yellowlegs, shorebirds, red-breasted sapsucker, varied thrush and hermit thrush (Armstrong 1990). Some additional likely prey, found in diets elsewhere (see above), also largely migrate out of southeast Alaska during winter: robins, mourning doves (rare even in summer), and northern flickers (uncommon even in summer) (Armstrong 1990). Obviously no nestlings of great blue herons would be available during winter.

Compared to the high plateau in northern Arizona where I studied goshawks for 7 years (Crocker-Bedford 1987, 1990b, 1991; Crocker-Bedford and Chaney 1988), in southern southeast Alaska potential prey are sparser during the breeding season and extremely sparse during the winter (pers. obs. 1989-1994). I believe this is the major reason why goshawk breeding densities in southeast Alaska (see below---Population Density and Trends, Southeast Alaska) are very sparse compared to those I found in northern Arizona (Crocker-Bedford and Chaney 1988, Crocker-Bedford 1990b, summarized in table 1 of this paper).

Habitat Structure and Composition

Goshawk literature is relatively consistent in regards to patterns of habitat use, especially for western coniferous forests. The goshawk has long been recognized as typically being dependent upon extensive forests and large stands of "heavy" timber (Bent 1937:127-128).

Stand Structure

Goshawks typically nest in taller mature or old-growth forest stands, either coniferous or deciduous, which have relatively dense canopies: in the Northeastern States (Allen 1978 as cited by Falk 1990, Speiser and Bosakowski 1987, Falk 1990, Kimmel and Yahner 1992); in Oregon (Reynolds et al. 1982, Moore and Henny 1983, Marshall 1992); in California (Saunders 1982, Hall 1984, Bloom et al. 1985, Fowler 1988); in Nevada (Herron et al. 1985 as cited by Fowler 1988); in Idaho and Utah (Hennessy 1978); in Idaho (Patla

1990); in northern Idaho and Montana (Hayward and Escano 1989, Warren et al. 1990); in South Dakota (Bartelt 1977, Erickson 1987); in Colorado (Shuster 1980); in Arizona (Crocker-Bedford and Chaney 1988, AG&F 1993); in New Mexico (Kennedy 1988); and in general (Jones 1981, Reynolds 1983, 1989).

Reynolds (1989:97) stated: "Preferred habitat during the breeding season is older, tall forests---deciduous, coniferous and mixed---where goshawks can maneuver in and below the canopy while foraging.." Crocker-Bedford and Chaney (1988) demonstrated preference (use compared to availability) for nesting in stands of large trees with dense canopies ($P < 0.0001$), and suggested such preference was associated with similar stands in the vicinity used for foraging. During summers in northern Arizona, 11 radio-tagged adult males showed increasing preference, on the average, for foraging as canopy cover increased from under 15%, to 15-33%, to 34-55%, to over 55% ($P < 0.001$, Mannan and Smith 1993). In northern California 10 radio-tagged goshawks avoided openings, stands of seedings and saplings, and sparse (<40% canopy cover) stands of sawtimber; they preferred dense (>40% canopy cover) stands of mature or old-growth trees ($P < 0.001$, Austin 1993). In eastern California, relocations of 10 goshawks were more frequent than expected by random chance where tree basal area was higher, canopy cover was denser, and tree stems were denser (Hargis et al. 1993), especially in the larger diameter classes (Hargis et al. manuscript). In Utah Fischer (1986) determined from radio relocations that 2 goshawks preferred to forage in stands of tall, mature and overmature trees. In the boreal forest of central Sweden in every season of the year, both adult males and adult females (A. g. gentilis) foraged significantly less in young and middle-aged stands than expected based on their availability ($P < 0.05$), and used mature forest approximately twice as frequently as its availability ($P < 0.05$)---and most successful foraging attempts were documented in mature forest (Widen 1989, and Widen 1987 as cited by Widen 1989).

Fischer and Murphy (1986) and Widen (1989) concluded that the preference for mature, taller forest was due to prey vulnerability and not prey abundance---their older forests did not exhibit higher prey densities so they concluded that the denseness of younger forests impaired goshawk hunting. Foraging success may also be impaired if the overstory is so sparse that the hunting goshawk is too visible to its prey (Widen 1989, Austin 1993) and has inadequate hunting perches (Austin 1993). In contrast, Reynolds and others (1992) suggested that prey abundance was more important than its accessibility. Most prey of goshawks inhabit the ground and shrub layer in a forest, though many prey are generalists found at any level of the forest (Reynolds and Meslow 1984, Mannan and Boal 1993). Following timber harvest, the change from larger trees to smaller trees may reduce the goshawk's ability to hunt successfully (Reynolds 1989, Widen 1989, Gullion 1990, Crocker-Bedford 1990b). Selection of foraging habitat appears to be a compromise between habitats that provide structures conducive to hunting and habitats which provide high prey densities (Widen

1989). Considerable habitat within the home range of a pair of goshawks must be of high enough quality to provide sufficient and accessible prey relative to the time and energy expended while hunting (Crocker-Bedford 1990b).

Relative to atricapillus goshawks, Queen Charlotte goshawks exhibit smaller size, more rounded wings, and proportionately longer tails, perhaps as adaptations to their dense rainforest environment (Whaley and White 1993). I suggest that Queen Charlotte goshawks should be affected by environmental variables similar to those affecting the goshawks in the above 4 paragraphs, but that Queen Charlotte goshawks can possibly cope with somewhat denser understory trees and more brush relative to A. g. atricapillus.

Radio study in southeast Alaska found habitat use trends similar to those discussed above. Of 667 independent relocations on 30 radioed goshawks (ADF&G 1994), 3.3% were recorded from natural openings and scrub forest, 1% from clearcuts and young second-growth forest, 3.6% from mature second-growth, and 92% from productive old-growth forest: 7.6% from riparian old-growth, 7.6% from beach fringe old-growth, 5.1% from mixed conifer old-growth, 2.7% from subalpine old-growth, and 69% from other old-growth away from streams and beaches. Of the 92% of the relocations from productive old-growth, 24% were Tongass National Forest (NF) volume class 4 (8-20 mbf/ac), 57% were Tongass NF volume class 5 (20-30 mbf/ac), and 12% were Tongass NF volume classes 6 and 7 (>30 mbf/ac). The 6 ecological provinces where goshawk relocations occurred (numbers 9, 10, 11, 13, 14 and 16 of the 1991 Supplemental EIS for Tongass Land Management Planning) averaged 45.2% natural openings and scrub forest, 6.9% clearcuts and young second-growth forest, 4.8% mature second-growth forest, 19.9% volume class 4 old-growth, 17.8% volume class 5 old-growth, and 5.5% volume class 6-7 old-growth (USDA Forest Service 1991a). Home ranges did not extend throughout the 6 ecological provinces, which reduces the precision of comparisons between percentages of relocations and percentages of habitat availability.

Nevertheless, the percentage of 667 independent relocations for the 30 radioed goshawks in southeast Alaska (ADF&G 1994), divided by the percentage of habitat availability in the 6 ecological provinces that they used, gives 0.07 for natural openings (open muskeg, meadows, rock, ice, ponds, and lakes) and scrub forest, 0.14 for clearcuts and young second-growth, 0.75 for mature second-growth, 1.2 for volume class 4 old-growth, 3.2 for volume class 5 old-growth, and 2.2 for volume class 6-7 old-growth. The percentage of relocations for two radioed goshawks from June 1992 to March 1993 in southern southeast Alaska (ADF&G 1993a), divided by the percentage of habitat in their actual home ranges (ADF&G 1993a), was 0.03 for natural openings and scrub forest, 0.18 for clearcuts and second-growth forest, 1.3 for volume class 4 old-growth, 3.2 for volume class 5 old-growth, and 1.4 for volume class 6-7 old-growth.

In general habitat preference increases with stand volume in southeast Alaska; however, volume classes 6-7 appear to be less preferred than volume class 5 old-growth. Timber harvesting 1950-1990 concentrated in volume classes 6-7 (USDA Forest Service 1991a), sc the residual volume classes 6-7 seem more likely to lie on steep slopes where the tree canopy extends closer to the ground and so may more likely impede hunting. I have also noticed that the existing stands of volume classes 6-7 tend to be smaller than volume class 5 stands, and Widen (1989---see one page below) found that goshawks prefer to hunt in larger stands.

Landscape Composition

Forest fragmentation appears to impact goshawks, at least in some cases. Closed forest should be contiguous enough to inhibit open-forest and forest-edge raptors, because timber harvesting allowed other raptors to usurp goshawk nest sites (Crocker-Bedford 1990b @ $P < 0.001$, Patla 1991, AG&F 1993) and can increase predation on goshawks (Moore and Henny 1983). In northern California goshawk nest stands larger than 160 ac are usually reoccupied, while those smaller than 160 ac are less likely to be reoccupied and those smaller than 40 ac are rarely reoccupied (Woodbridge 1988, Woodbridge and Detrich 1993). Timber harvesting in the home range beyond the nest stand can significantly affect reoccupancy of the nest stand (Crocker-Bedford 1990b, 1991, Patla 1991, Ward et al. 1992---see section on Population Densities and Trends). In Connecticut, goshawks nested an average of 6 mi from the nearest opening larger than 13 ac (5 ha)---farther from openings than any of the other hawks (Falk 1990). The importance of extensive forest was also found in New York and New Jersey, where nests usually occurred in "wilderness areas" (Speiser and Bosakowski 1987). In Pennsylvania goshawk home ranges exhibited significantly more forest cover than randomly chosen 4,840-acre plots, and nest sites averaged significantly farther from openings than randomly chosen points (Kimmel and Yahner 1992). In Germany goshawks typically nest farther from openings than do other hawks (Kostrzewa 1987 and Gemauf 1988, as cited by Falk 1990).

In contrast, half the nests in northern Idaho and Montana were within 0.3 mi from openings larger than 3 ac (Hayward and Escano 1989); however, the authors suggested that some results of their study were probably biased because many nests were located during timber harvest operations. Goshawks have been known to successfully nest in a shrub-steppe ecosystem having only 10% tree cover by riparian aspen (Populus tremuloides) (Younk and Bechard 1992). An unusual proportion of the nesting females were only two years old (Younk and Bechard 1992), which may have indicated immigration to utilize an unusually high density of ground squirrels, rather than a long-term population of productive goshawks (Younk pers. comm. Nov. 1992). Furthermore, subadult goshawks and subadult Cooper's hawks (A. cooperii) are sometimes displaced into nontraditional and marginal nesting habitats (McGowan 1975, Moore and Henny 1984). A pair of goshawks was reported nesting in a riparian feltleaf willow (Salix alaxensis)--

balsam poplar (P. balsamifera) stand surrounded by tundra, but such habitat was apparently "marginal" for goshawks as it was used only 1 year in 12 and then produced only 1 young (Swen and Adams 1992).

Mannan and Smith's (1993) radio-telemetry study found that some goshawks spent significantly more time in denser forest over 200 m from open forest than was expected given the habitat availability. Widen's (1989) radio-telemetry study did not find different preferences for different sizes of clearcuts, nor for different sizes of stands of young forest, nor for sizes of stands of middle-aged forest; however, patch size was a significant factor in the selection of mature forest. The Swedish goshawks used mature forest patches larger than 100 acres 10 times more intensively, on a per acre basis, than mature stands smaller than 50 acres ($P < 0.001$). In contrast, in mixed woodland/agricultural areas Kenward (1982) found that goshawks preferred hunting and were more successful hunting in woodland within 200 m of openings, though his result could have been due to his radioed goshawks feeding on high densities of pheasants (Phasianus colchicus) and brown hares (Lepus europaeus). The different use of edge in coniferous forest and in deciduous woodland mixed with agricultural openings, most probably reflected the different prey available (Kenward and Widen 1989).

Only one of Mannan and Smith's (1993) birds in northern Arizona used habitat diversity categories in a manner statistically different from random---this bird tended to avoid locations near a wide variety of stand conditions. In contrast, in eastern California goshawk home ranges contained more seral diversity than was typical (Hargis et al. 1993).

Habitat Summary

Large trees are important for nesting and perching (Bartelt 1977, Hennessy 1978, Shuster 1980, Reynolds et al. 1982, Saunders 1982, Moore and Henny 1983, Hall 1984, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988, Kennedy 1988, Hayward and Escano 1989, Patla 1990). Stands of large trees tend to offer more goshawk flight space beneath their canopies and between tree trunks (Moore and Henny 1983, Fischer and Murphy 1986, Speiser and Bosakowski 1987, Hayward and Escano 1989, Reynolds 1989, Widen 1989, Crocker-Bedford 1990b, Warren et al. 1990), and large trees improve the abundance of some prey species (Crocker-Bedford 1990b, Warren et al. 1990, Reynolds et al. 1992). Closed forest canopy apparently provides preferred microclimate in the nesting stand (Bartelt 1977, Hennessy 1978, Reynolds et al. 1982, Hall 1984, Erickson 1987, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988), possible inhibition to predators in the nesting stand (Reynolds et al. 1982, Moore and Henny 1983), and apparently reduces nest site competition by other raptors (Crocker-Bedford and Chaney 1988, Crocker-Bedford 1990b, Ward et al. 1992, AG&F 1993). Also, closed canopies may be associated with overall prey abundance (Crocker-Bedford and Chaney 1988, Crocker-Bedford 1990b, Warren et al. 1990)---or at least the abundance of certain key prey (Reynolds et al. 1992)---and the ability of goshawks to sneak up to their prey (Widen 1989, Austin 1993). In any case, goshawks spend a disproportionate amount of time in stands with greater canopy closure (Hargis et al. 1993, Austin 1993, Mannan and Smith 1993). The sparseness of shrubs and small trees appears to facilitate goshawk flight (Moore and Henny 1983, Fischer and Murphy 1986, Speiser and Bosakowski 1987, Widen 1989, Crocker-Bedford 1990b, Warren et al. 1990, Reynolds et al. 1992) and possibly facilitates prey capture (Reynolds and Meslow 1984, Fischer and Murphy 1986, Speiser and Bosakowski 1987, Reynolds 1989, Widen 1989, Crocker-Bedford 1990b, Gullion 1990, Warren et al. 1990). Goshawks prefer to hunt in mature forest (Fisher and Murphy 1986, Widen 1989, Austin 1993, ADF&G 1993a, 1994), especially in mature stands larger than 100 acres (Widen 1989). The amount of area with the above attributes, within a home range, may increase the energy intake to expenditure ratio of goshawks (Crocker-Bedford 1990b, Warren et al. 1990).

HOME RANGE/TERRITORY

Literature as of 1983 generally showed goshawk breeding home ranges between 5,000 and 8,000 ac (Reynolds 1983). In northern New Mexico for June to September, Kennedy (1989) found that the 95% harmonic-mean home ranges of 3 adult males were 4,200, 4,400, and 7,000 ac, while those of 5 adult females averaged 1,400 ac (range = 230-3,200 ac). In northern Arizona for June to August, Mannan and Smith (1993) found that the 95% harmonic-mean home ranges of 11 adult males averaged 3,800 ac (range = 2,100-5,700 ac), while the minimum convex polygon method showed 4,400 ac (range = 2,200-6,200 ac). In northern California for July to August, Austin (1993) found that the minimum convex polygon method averaged 6,000 ac (range = 2,700-9,600 ac) for 5 adult males, 9,300 ac (range = 5,000-17,100 ac) for 5 adult females, and 11,800 ac for pairs. The largest home range (17,100 ac) corresponded to the most fragmented habitat (K. Austin pers. comm.) In eastern California during summer, the average home range of 10 nesting goshawks was 2,200 ac as calculated by the adaptive kernel method (Hargis et al. 1993), which highlights areas of concentrated use and tends to show less area.

In southern southeast Alaska the home range of one pair of goshawks, from Prince of Wales Island, was an order of magnitude larger than those measured elsewhere. ADF&G (1993a) used radio relocations with the minimum convex polygon method for home ranges. From 17 June to 10 August 1992, 32 relocations of an adult male encompassed 46,700 ac of which 26,500 ac were land, and 24 relocations of an adult female encompassed 59,300 ac of which 25,700 ac were land. The 56 relocations of the pair during summer encompassed 101,600 total ac of which 50,800 ac were land.

ADF&G (1994) reported on two additional pairs from south of Frederick Sound, tracked during the breeding season of 1993. The Kuiu Island adult male ranged over 15,400 ac (zero salt water), the female over 26,700 ac (73% land), and the pair over 36,900 ac (81% land). The Kupreanof Island male ranged over 21,000 ac (zero salt water), the female over 275,300 ac (67% land), and the pair over 288,700 ac (68% land). The percentages of land were my calculations from maps, and result in 29,900 ac and 184,500 ac of land for the nesting season home ranges of the two pairs.

A partial explanation for the huge home ranges in southern southeast Alaska (ADF&G 1993a, 1994), relative to studies elsewhere (3 paragraphs above), is that relocations in southeast Alaska were made from aircraft (ADF&G 1993a, 1994). Other studies relocated radioed goshawks from ground vehicles, and seem more likely to have missed birds when they were farther from their nests. Still, I believe the primary reasons for the huge home ranges in southern southeast Alaska are prey and habitat effects which stem from both natural and anthropogenic factors.

The adult goshawks studied in northeastern southeast Alaska were all from the general area of Juneau. They were each relocated only 8-14 times prior to post-nesting dispersal, so significant amounts of their home ranges were probably beyond the measured minimum convex polygons (ADF&G 1994). The 5 males averaged 6,000 ac (range 1,800-11,100 ac), the 5 females averaged 3,400 ac (range 700-9,400 ac), and the 5 pairs averaged 8,800 ac (range 4,800-12,700 ac). Although more relocations will almost certainly increase the home range sizes, it still appears that goshawks in the Juneau area had smaller home ranges. This may have been due to more prey of optimum size in the Juneau area (see section on Food Habits). Breeding home ranges of all pairs, both south and north, might have been larger if there had been data from the courtship, incubation and early nesting periods (ADF&G 1994).

The ADF&G (1993a) report is the only one of which I know for North America which shows home ranges from summer through winter. From 17 June 1992 to 10 March 1993, 51 relocations on the adult male encompassed 169,200 ac of which 75,700 ac were land, and 45 relocations on the adult female encompassed 243,800 ac of which 174,700 ac were land. Combining all 96 relocations of the pair from June to March gave 390,000 total ac of which 195,000 ac were land. From September to June in the boreal forest of central Sweden (Widen 1985), the minimum convex polygon of 23 adult males averaged 12,600 ac (range = 4,400-19,800 ac) while the home range of 20 adult females averaged 15,300 ac (range = 7,900-22,700 ac).

Goshawks defend against humans 20-25 ac around each of their nests (Reynolds 1983). Unless habitat is altered, a pair apparently defends against other raptors a territory which surrounds all of the pair's cluster of alternate nests (Crocker-Bedford 1990b). The territory defended against conspecifics may be larger (Crocker-Bedford 1990b).

Austin (1993) found that the average density of goshawk pairs was similar to that which could be inferred from the mean size of their summer home range (1 pair/13,000 ac in her study area versus a mean home range [minimum convex polygon] of pairs during summer of 11,800 ac. In northern New Mexico, Kennedy (1989) found one occupied territory per 8,800 ac (some occupied only by a female without a male), while the measured home ranges there averaged less than half that much. In southeast Alaska nesting season home ranges showed little overlap between adjacent pairs (ADF&G 1993a:17, 1994 maps). Although summer home ranges of some adjacent pairs can sometimes overlap by as much as 20% (Mannan and Smith 1991), the mean summer home range may be an indicator of the maximum actual density of a goshawk population.

POPULATION DENSITIES AND TRENDS

The reported breeding densities that are summarized in Table 1 for western North America should be used with caution because survey techniques and intensity varied between studies. Also, given the different forest types and prey compositions found in different locales, one would expect different densities of goshawks even without human induced habitat changes. For this reason, perhaps the only useful comparisons in regards to amount of logging are those within a certain geographical area (e.g. within northern Arizona and northern New Mexico; or within California).

Southeast Alaska

The first section of this paper---on Distribution and Population Status---concluded that a rough estimate of the current goshawk population in southeast Alaska is 100-200 pairs. This would equal 0.2-0.4 pair per 10,000 acres of forest denser than 8 mbf/ac, or 0.05-0.1 pair per 10,000 ac of all land in southeast Alaska. The section on Distribution and Population Status also related that habitat capability in southeast Alaska may have fallen by over 30% due to past logging. Still, it agreed with Forsman (1994) that all we know for sure about the population of southeast Alaska is that goshawks "are relatively rare, and that they are probably declining as a result of habitat loss."

Of 30 known, probable and possible nest sites identified by the end of 1992 in southeast Alaska, 70% had already been harvested or were in the vicinity of planned timber harvesting (ADF&G 1993a). If one considers only the 18 nest sites identified during activities not associated with timber harvest, then 61% had already been harvested or were in the vicinity of planned timber harvest (ADF&G 1993a).

British Columbia

In British Columbia, breeding Queen Charlotte goshawks only occur on coastal islands and perhaps on the mainland's coast. Goshawks are sparser in coastal British Columbia than in the interior (Campbell et al. 1989). The rate of loss of goshawk habitat in coastal British Columbia far exceeds that of southeast Alaska (Crocker-Bedford 1990a).

By 1990 coastal British Columbia had 12,682,000 ac of productive old-growth forest and 6,832,600 ac of clearcuts and second-growth forest (Imre Spandli, Ministry of Forestry, British Columbia, pers. comm. 1990). The coastal mainland portion of this landscape tends to be used by A. g. atricapillus rather than laingi (R. W. Campbell, pers. comm. 3 May 1994), so much of this landscape is really not available to produce Queen Charlotte goshawks. Of 90 watersheds larger than 12,500 ac on Vancouver Island, only 6 remained unlogged by 1992 and 5 of those were planned for entry by 1997 (Frost and Friedman 1992). The annual timber harvest over the entire Province of British Columbia now averages about 17 billion board feet, and half of all timber ever harvested in British Columbia has been harvested since 1977 (Frost and Friedman 1992).

The Federal Government of Canada (1991:p.7/27) concluded:

> "the loss of old-growth forests [in Canada] is most dramatic in the coastal rain forests... At the current rate of logging, it is estimated that there will be no substantial ancient forest left on the British Columbia coast by the year 2008. ... Pacific Rim National Park Reserve and South Moresby/Gwaii Haanas National Park Reserve are the only national parks protecting virgin coastal rain forest in Canada. Most of the old growth bordering Pacific Rim is destined for clear-cutting, which will reduce the park stands to narrow ribbons of forest, once again raising the size issue and potential problems of biogeographic isolation. Carmanah Creek, the site of Canada's tallest trees,...is currently in the process of being set aside as a provincial park."

Steller's jays are typically a common food of Queen Charlotte goshawks (see Food Habits), but Steller's jays have declined greatly on the Queen Charlotte Islands and are now rare there (West 1993, R. W. Campbell pers. comm. 3 May 1994). Only 3 documented nest sites of A. g. laingi persist on the Queen Charlotte Islands, and no breeding has been recorded there for 6 years (R. W. Campbell pers. comm. 3 May 1994). A. g. laingi has become so rare in British Columbia that it could perhaps be eliminated from its range there by the collectors of eggs and specimens (Ibid.).

Washington

After several years of surveying for goshawks and northern spotted owls (Strix occidentalis caurina) in western Washington, R. Lowell (now ADF&G goshawk biologist) opined that goshawks in western Washington are rarer than spotted owls, and goshawks appear to be more adversely affected by forest fragmentation than are northern spotted owls (pers. comm.). Lowell usually found spotted owls in areas where he found goshawks, but he did not find goshawks in most areas that had spotted owls. He found no goshawks in highly fragmented landscapes.

Goshawks of the Olympic Peninsula are possibly the Queen Charlotte subspecies (see earlier section on Distribution). Goshawk viability on the Olympic Peninsula is of particular concern because they "are believed to be relatively isolated there, they occur in low numbers, and their habitat requirements have not been well documented" there (Thomas et al. 1993:290). Within the range of the northern spotted owl, the northern goshawk is one of the three bird species with the highest viability risk from timber management (Thomas et al. 1993:416).

Although no firm population trend data were available, logging and suppression of understory fires contributed to a general decrease in nesting and foraging habitat for goshawks in Washington and Oregon (Marshall 1992). Management provisions for goshawk foraging ranges were inadequate, so questions remained on the long-term viability of goshawks in Washington and Oregon (Marshall 1992).

Oregon

Reynolds and Meslow (1984) suggested that the lack of nesting goshawks in northwestern Oregon was possibly due in part to extensive past timber harvesting and wildfires in that geographic area; however, Forsman (1994) suggested that goshawks never occurred in northwestern Oregon.

Mannan and Meslow (1984) concluded that goshawks could possibly be extirpated from northeastern Oregon if the old-growth forest stands allocated to timber harvest were actually logged.

California

The breeding population of goshawks in California was estimated to have decreased one-third by 1985, mostly because of timber harvesting, and the decline was continuing at about 1% per year (Bloom et al. 1985). The goshawk was once common during winter in southern California, but is now very rarely seen there (Bloom et al. 1985).

Forest management practices often degrade goshawk nesting and foraging habitats, especially in the more mesic coastal forests of northern California, "despite alternative techniques that [strive to] mimic or use natural processes to maintain necessary structural characteristics" (Woodbridge et al. 1993). In mesic coastal forests suppression mortality of the understory is important for the understory to be open enough for quality hunting habitat (Woodbridge et al. 1993), and suppression mortality is related to the density of the overstory canopy. These concepts imply that goshawk habitat may even be degraded by selection harvesting in the overstory of an old-growth rainforest, such as in southeast Alaska.

Idaho

In Idaho, Patla (1990) found a loss of nesting sites from logging, despite standards meant to protect the nesting sites. Another analysis (Patla 1991) indicated that timber harvesting within 1/4 mi of protected nest sites resulted in a 75-80% reduction in goshawk occupancy of nesting territories. Actual losses were probably higher because of the harvesting of unknown nest trees. Vacated nests were often taken over by other raptors.

Northern New Mexico

Goshawks in New Mexico appeared to be "threatened" as a result of low reproductive success and low density (Kennedy 1989). Removal of old-growth habitats probably reduced the historic population of goshawks in this area (Kennedy 1988). Four of 16 territorial females were without mates (P. Kennedy, Colo. State Univ., pers. comm.). Perhaps the population density had been reduced so much (i.e., only 1.1 nesting female per 10,000 ac) that the opportunity for pairing had been reduced, as theorized by Lande (1987, 1988).

Northern Arizona

Timber harvesting under a selection-harvest regime, in which one-third of the timber volume was cut, was associated with a decrease in goshawk reproduction ($P < 0.001$, Crocker-Bedford 1990b). Pair occupancy exhibited a measured decrease of 75% relative to the controls ($P = 0.003$), despite no-cut nest buffers of 3-500 ac (mean = 95 ac) in the treated locales. Fledglings per nest attempt showed an additional decrease of 75% ($P = 0.003$). Other raptors replaced goshawks in most logged territories but not in any control territory ($P < 0.001$). Goshawk foraging habitat may have been degraded by the loss of large trees and by an increase in shrubs, saplings and small trees (Crocker-Bedford 1990b).

These and other data were analyzed (Crocker-Bedford 1991) to determine the decline in nesting and reproduction as compared to the amount of timber harvesting from 1973 to 1986 within assumed, circular home ranges ($n = 53$) of 5,800 ac. Selection harvesting in 10-39% of the stands in a home range was associated, on the average, with 50% less reproduction than in home ranges receiving little or no harvesting ($P < 0.02$). Selection harvest in 40-69% of the stands in a home range resulted, on the average, in an 80% decrease in reproduction. Compared to unharvested home ranges, only 11% as much occupancy ($P < 0.001$) and no reproduction occurred where selection harvest extended over 70% or more of the stands in a home range. While the effect of harvesting within the home range was great ($P < 0.001$), whether or not selection harvesting occurred in the nest stand had no measurable effect ($P = 0.78$).

The density of pairs in locales not logged since 1972 indicated that the 1972 population of the North Kaibab Ranger District was roughly 130 pairs (Crocker-Bedford 1990b) or, more accurately, 170 $\pm$40 pairs (Crocker-Bedford unpub. rep. August and Sept. 1991). Since 1972 the breeding population was estimated to have dropped by half (Crocker-Bedford 1990b). In 1992, after years of intensive breeding surveys, researchers knew of 58 occupied breeding areas (74% of which successfully fledged young) on the District, and "few additional breeding areas [were] expected to be located on the [District] due to the intensity of recent survey efforts" (Heslin et al. 1993:14).

Boyce and others (unpubl. manuscript Apr. 1993) reported on changes 1987-1992 in the territories studied by Crocker-Bedford (1990b):

> "For control territories [Crocker-Bedford's unlogged territories] that were treated after 1987 [Crocker-Bedford's last year], we see them becoming unoccupied shortly after treatment."

Boyce et al. (Ibid.) also provided 1991-1992 data for Crocker-Bedford's active (egg producing) control territories of 1987. Of those which had still not received harvesting, 89% remained active 1991-1992. Of those with timber harvesting 1988-1992, only 40% remained active 1991-1992. Despite these results the same authors, in an abstract for a presentation (Boyce et al. 1993), "could not find a significant pattern of change in the number of control and treatment territories that were occupied."

Also on the North Kaibab Ranger District, Ward and others (1992) assessed aerial photographs from 1972 and the late 1980's for canopy coverage of areas (up to 2,500 acres) around a sample of goshawk nest clusters. Goshawk territories which became inactive by the late 1980's had significantly less canopy density (= greater logging) by the late 1980's than did territories which remained active ($P < 0.10$).

By 1992 the North Kaibab Ranger District still had much more mature forest and produced more fledglings per nest attempt ($P = 0.03$) than did the South Kaibab, which received heavy timber harvesting decades ago and is now dominated by a younger forest (AG&F 1993).

Eastern United States

Although significant numbers of goshawks (mostly from Canada) sometimes winter in the eastern United States, breeding densities were greatly reduced throughout the eastern States (Bent 1937). The goshawk was extirpated south of the Lake States and Pennsylvania (Jones 1981). The recovery and maturation of many forests in the East may explain the recent range expansion of the goshawk in Michigan (Postupalsky 1975 as cited by Speiser and Bosakowski 1987) and the Northeast (Speiser and Bosakowski 1987), as well as the recolonization of the Appalachian Mountains nearly to Georgia (Johnsgard 1990).

Given the goshawk's persistence in parts of the Northeast despite the extent of past forest harvest there, the concern for the viability of the Queen Charlotte goshawk might appear unwarranted. However, hardwood and mixed broadleaf/conifer ecosystems in the Northeast may produce more usable goshawk prey at earlier stand ages than do western coniferous forest ecosystems. Coniferous forests tend to go through a long second-growth stage with few understory plants, while second-growth broadleaf forests typically continue to produce many herbs and shrubs. The forage, seed and berry production in immature broadleaf forests may support larger prey populations than do immature coniferous forests. Furthermore, prey in young broadleaf forests may be more available, because second-growth coniferous forests include a longer period when canopies extend to the ground, thereby impairing maneuverability by goshawks and providing prey escape cover.

Finally, goshawk populations in the Northeast and Great Lake's States have possibly benefited from the periodic invasions of Canadian goshawks of the same subspecies. No such population reservoir exists for the Queen Charlotte subspecies.

Comparison with Europe

Although goshawks (A. g. gentilis) were extirpated from Great Britain (Kenward et al. 1991) and southern Europe, they persisted in northern Europe despite significant logging and land conversion there. Such persistence in Northern Europe may be due to the key prey there occupying different habitats. Also anthropogenic changes there occurred over many centuries, so perhaps goshawks and some prey had time to adapt to the changing ecosystem.

Persistence of goshawks in northern Europe may also be due to the fact that Old and New World goshawks differ morphologically. They may be different species (Brown and Amadon 1968, Beebe 1974).

MOVEMENTS/DISPERSAL

Adults

Several lines of evidence indicate incomplete mixing within the subspecific range of the Queen Charlotte goshawk. Beebe (1974) stated that they are resident and do not migrate. Whaley and White (1993) found that the goshawks of coastal British Columbian islands had more rounded wings than most goshawks of North America, and they related this in part to the more sedentary nature of Queen Charlotte goshawks. None of the 17 adult goshawks radio-tagged at nest sites migrated out of southeast Alaska during fall or winter (ADF&G 1993a, 1994). Although goshawks of interior Canada may travel hundreds of miles during food shortages, those of western British Columbia (including the Queen Charlotte subspecies) move little (Beebe 1974).

Working with other subspecies McGowan (1975) and Widen (1985) found that adult goshawks usually did not shift their breeding territories, but Detrich and Woodbridge (1993) found that some females moved to other home ranges. Even adult goshawks from northern latitudes were usually resident on their territories year-around (McGowan 1975, Widen 1985). Non-breeding adults without territories also were usually resident year-around (Widen 1985). In south-central Sweden when food shortages induced adults to cease defending their breeding territories during some winters, adults usually travelled less than 60 mi from their nests (Widen 1985).

When adults do leave their residences for winter, the sexes often go separately (Widen 1985). It was thought that goshawks were pair-bonded until one dies (Brown and Amadon 1968, Palmer 1988, Johnsgard 1990) which would imply they would return to the same breeding range after winter; however, some mate switching does occur in northern California (Dietrich and Woodbridge 1993). Forsman (1994) suggested that the male and female each defend a territory against members of their own sex, but will pair with a new mate in the event their previous mate dies or is driven out by the future mate.

The above discussion implies that vacant habitat and unpaired potential mates may not be found immediately---at least if they are very far away (Lande 1988). Also, genetic interchange across the subspecific range of Queen Charlotte goshawks is likely incomplete, as evidenced by slightly different morphologies in different populations (see section of Distribution and Population Status). Moreover, given the home range philopatry and the different morphologies of A. g. laingi and A. g. atricapillus, I doubt that significant mixing occurs between adults of the two subspecies across the wide and high coastal mountains of southeast Alaska and British Columbia.

Juveniles

In Gotland, Sweden, by 1 January the maximum distance which juveniles moved from their nest depended on their sex and, for females, the abundance of rabbits in their natal territory: the average maximum distance for males was 17 mi (n = 7) in rabbit rich areas and 18 mi (n = 20) elsewhere; the average maximum distance for female young was 5 mi (n = 12) in dense rabbit areas and 13 mi (n = 22) elsewhere (Kenward et al. 1993b). In central Alaska, recoveries of 8 banded juveniles indicated average dispersal of 12 mi (McGowan 1975), though in south-central Sweden 6 of 8 juveniles dispersed over 30 mi (Widen 1985). With a much larger sample size (303 recoveries), Hoglund (1964 as reported in Widen 1985) determined that 44% of the juveniles in northern Sweden dispersed more than 30 mi. In contrast, only 4% of the juveniles in Germany dispersed over 30 mi (Glutz et al. 1971 as reported in Widen 1985). Many of the juvenile recoveries were during winter, so in the spring many of the juveniles might have returned to the general vicinities where they were fledged, as do so many birds.

In southeast Alaska by 13 January 1994, the farthest that 11 juveniles had traveled from their nests ranged from 10 to 94 mi (mean = 40 mi, median = 32 mi). The authors (ADF&G 1994) cautioned that actual dispersal distances could not be calculated until the juveniles eventually established breeding territories.

Dispersal by juvenile Queen Charlotte goshawks may be too little to assure frequent mixing across some of the bodies of water within the subspecific range. The different morphological characteristics associated with different portions of the subspecific range (see section on Distribution) indicates that juvenile dispersal is inadequate to ensure full mixing within the subspecies range. Given the dispersal data and different morphologies of A. g. laingi and A. g. atricapillus, I doubt that significant mixing occurs between the two subspecies across the wide and high coastal mountains of southeast Alaska and British Columbia.

Vacant suitable habitat patches may not be found if they are too few, small or isolated relative to the number of dispersing juveniles and dispersal distances (Lande 1988).

Post-Fledging Period

Much attention has been paid to special management of the post-fledgling family area or PFA (USDA Forest Service 1991b, Reynolds et al. 1992). Reynolds et al. (1992:13) cited Kennedy (1989, also her Ph.D. diss. which I label 1990) to assert that the PFA is

> "an area used by the adults and young from the time the young leave the nest until they are no longer dependent on the adults for food... PFA's vary in size from 300 to 600 acres (mean = 415 acres) and may correspond to the territory (a defended area) of a pair of goshawks."

Although Kennedy (1989) did determine a mean core area of 415 ac for 5 adult females during summer, she did not have any young radio-tagged and so could not state the area used by young. Adult females, and especially adult males, spent much time beyond the female core area. I found nothing in her papers (Kennedy 1989, 1990) to indicate that the core area of the female was defended against other goshawks.

In southeast Alaska adult female goshawks typically abandon their nest sites, and often disperse from their breeding ranges, within a few days after their young fledge. The adult males continue to feed the young, apparently until young disperse about 39 days after fledging (ADF&G 1993a, 1994). Desertion by female Cooper's hawks, shortly after their young fledged, tended to occur for the females which were in poorer physical condition (Kennedy 1990).

A detailed radio study of post-nestling behavior of goshawks in Gotland, Sweden (Kenward et al. 1993a) found that young rarely ventured more than 1000 ft (the area used must have been under 70 ac---the size in the unlikely case that young flew 1000 ft in all directions) from their nests for their first 25 days after fledging, and that essentially all food was provided by their parents during this period. Young then abruptly increased their movements over the next few days, though most of their food continued to be brought from farther away by their parents. For 80% of the juvenile males, dispersal out of their parents' nesting ranges occurred between 30 and 40 days after fledging in a rabbit rich area, and 3 days earlier in a rabbit poor area. Average dispersal for young females was 40 days after fledging. Juvenile dispersal was associated with the start of active hunting. Kenward et al. (1993b) found that only 3% of the juvenile males (n = 73) and 8% of the juvenile females (n = 83) died between fledging and dispersal (Kenward et al. 1993b).

It seems that concern for the young in the post-fledging area has perhaps been over emphasized in Forest Service management. The quality of late winter and early spring foraging habitat, and prey abundance, affects the breeding condition of the adult female

(Palmer 1988), and the largest effect on reproduction is failure to nest (Postupalsky 1974 as cited by Austin 1993, Crocker-Bedford 1990, 1991). Moreover, the male provides almost all food for the entire family from April or May through July; therefore, the quality of his foraging range may affect the amount of time that the female can protect their young (Kennedy 1990), the number of young which can be fed, and the growth rate of their young. Below I will recommend that more emphasis be placed on foraging habitat, whether within or beyond the post-fledging area.

VIABILITY and DISTRIBUTION CONCERNS

Timber Harvest Effects

Many authors have asserted that timber harvesting, especially that near nests, has the potential to adversely affect goshawks: in Oregon (Reynolds et al. 1982, Moore and Henny 1983, Mannan and Meslow 1984, Marshall 1992); in California (Saunders 1982, Hall 1984, Bloom et al. 1985, Fowler 1988, Woodbridge 1988, Austin 1993); in Nevada (Herron et al. 1985 as cited in Fowler 1988); in Idaho and Utah (Hennessy 1978); in Idaho (Patla 1990, 1991); in Montana and Idaho (Warren et al. 1990); in South Dakota (Bartelt 1977, Erickson 1987); in Arizona (Crocker-Bedford 1987, 1990b, 1991, Crocker-Bedford and Chaney 1988, Zinn and Tibbitts 1990, Ward et al. 1992, AG&F 1993, Mannan and Smith 1993); in New Mexico (Kennedy 1988, 1989); and in general (Jones 1981, Reynolds 1983, 1989, Reynolds et al. 1992).

Goshawks tend to nest in habitat which humans value for potential lumber. Of 30 known, probable and possible nest sites identified by the end of 1992 in southeast Alaska, 70% had already been harvested or were in the vicinity of planned timber harvesting (ADF&G 1993a). That percentage decreases to 61% if one considers only the 18 nest sites identified during activities not associated with timber harvest (ADF&G 1993a).

Furthermore, reductions in nest occupancy or reproduction following logging, even given protection of nest sites (Woodbridge 1988, Woodbridge and Detrich 1993) or nesting stands (Crocker-Bedford 1990b, 1991; Patla 1991; Ward et al. 1992; AG&F 1993), have demonstrated that timber management can negatively affect the forest habitat mixture that is necessary for goshawks beyond nest sites or nesting stands. One hypothesis, which would explain decreases in reoccupancy following logging even where nest sites are protected, is that goshawks are unable to expand their home range and time foraging enough to fully compensate for the losses of key foraging habitats. In addition to limitations of energetics, it may be that a pair of goshawks can expand their breeding home range only if an adjacent territory is vacant---the adjacent pair has abandoned or died---thereby making available additional, key foraging stands.

The male must provide almost all the food for the entire family from May through July. The male's home range is typically large which implies that, even given relatively abundant food, it is already difficult for him to gather enough food to feed the family. Consequently, the loss of foraging stands may affect reproduction more severely than implied by the simple proportion of a home range that is harvested (Crocker-Bedford 1990b, 1991, Patla 1991).

Harvesting a portion of a home range can either eliminate nesting, have no measurable effect on reproduction, or have an intermediate effect (Crocker-Bedford 1991, Patla 1991). This may be explained by the fact that goshawks do not use their home ranges evenly (Fischer 1986, Kennedy 1989, Widen 1989, ADF&G 1993a and 1994, Austin 1993, Hargis et al. 1993, Mannan and Smith 1993). Some stands are used more than others, even if their gross vegetation structure is similar (Kennedy 1989, Widen 1989, raw data of ADF&G 1993a and 1994, Hargis et al. 1993). I theorize that whether or not goshawk reproduction is adversely affected by timber harvesting within a home range, is related to the number of key foraging stands which are negatively impacted, as well as the continued presence of alternative, high quality foraging stands. In other words, the location of timber harvest is as important as the amount of harvesting.

The earlier section on "Population Densities and Trends" cites numerous examples of timber harvesting adversely affecting goshawk nesting, breeding densities, or reproduction. The examples vary from strong science to weak inference, but taken together provide a strong pattern.

Evidence exists that timber harvesting and land conversion can contribute to the extirpation of goshawks from large regions. Loss of forest contributed to the extirpation of goshawks from Great Britain (Kenward et al. 1991). Also, Jones (1981) believed that goshawks had been severely reduced in the northeastern United States and extirpated south of Pennsylvania. His contention is supported by the fact that where second-growth forests have matured, goshawks have expanded their range in Michigan (Postupalsky 1975 as cited by Speiser and Bosakowski 1987) and the northeastern states (Speiser and Bosakowski 1987), and recolonized the Appalachian Mountains almost to Georgia (Johnsgard 1990). The large population reservoir of <u>A. g.</u> atricapillus in Canada may have contributed to the recent partial recovery of goshawks in the eastern United States; however, no such population reservoir exists for the insular Queen Charlotte goshawk.

In southeast Alaska logging has tended to concentrate in the tracts of landscape that were probably high quality for goshawks. This was especially true on private lands. Of the existing National Forest lands, in 1954 there were 173 watersheds (Forest Service VCU's) more than 66% covered by old-growth of more than 8 mbf/ac, but by 1988 only 81 watersheds (VCU's) were over 66% old-growth (Crocker-Bedford 1990a). Compared to 40 years ago, most residual tracts of landscape with some potential for use by goshawks are more naturally fragmented with unsuitable habitats (rock, ice, open water) and low quality habitats (shrubby forests and forested muskegs < 8 mbf/ac), or are fragmented with clearcuts and second-growth so short and dense that goshawk flight is encumbered.

Furthermore, until recently logging concentrated almost entirely in the higher volume timber stands, and generally avoided the lower volume "commercial" timber stands (USDA Forest Service 1991a) which are less preferred by goshawks (ADF&G 1993a, 1994, and see section on Stand Structure). In fact, considering all stands within the Tongass NF, whether or not in Land Use Designations available for timber harvest, 39% of the stands with over 30 mbf/ac had been harvested by 1990 while close to zero percent of timber stands having less volume had been harvested (USDA Forest Service 1991a). In addition, State and Native selections of lands from the Tongass NF totaled 681,000 acres by 1991 (USDA Forest Service 1991a), emphasized high volume timber stands, and had received 150,000 acres of harvesting by 1990 (Crocker-Bedford 1990a).

Habitat degradation may partially explain why radioed pairs exhibited larger home ranges in southern southeast Alaska (see section on Home Range/Territory), which has been more heavily logged. Larger home ranges imply sparser breeding densities (see section on Home Range/Territory), which may lead to lower survival as well as reduced occupancy of the residual suitable or marginally suitable home ranges (Lande 1988, Thomas et al. 1990).

Large areas of clearcuts and young-growth forest have been added to the naturally unsuitable habitats of water and ice and low quality scrub forest in southeast Alaska. This has tended to reduce the sizes and number of landscapes having habitat mixtures suitable for breeding goshawks. Having fewer and smaller suitable landscapes results in greater average distance between the residual suitable landscapes. Smaller suitable landscapes which are farther apart implies fewer pairs, slower recolonization of vacant suitable home ranges, and less chance of a widowed bird gaining a mate, and also causes seemingly suitable home ranges to be unoccupied much of the time (Lande 1987, 1988, Thomas et al. 1990).

Population Size and Trend

The Queen Charlotte goshawk in southeast Alaska might be surviving as two intermixing populations largely isolated from those in Canada (see Distribution and Population Status). The segregation of a low total population of a subspecies into smaller subpopulations, along with population declines, increases the chance of local extirpation and possible extinction of an entire subspecies (Mace and Lande 1991).

Reed et al. (1986) calculated that at least 610 interbreeding pairs of goshawks are necessary to assure long-term genetic viability. If true, then the existing population of Queen Charlotte goshawks in southeast Alaska is already below that figure, and it may be that very little mixing occurs with Queen Charlotte goshawks in

Canada (see Distribution and Population Status). More importantly, other threats usually require that a viable population be much larger than that needed simply for genetic viability (Lande 1988).

The Queen Charlotte subspecies as a whole, including Canadian birds, meets Mace and Lande's (1991) criteria for "vulnerable" to extinction: under 5,000 pairs and over 1.0% annual decline in habitat capability (see Distribution and Population Status). The Alaska Natural Heritage Program ranked the Queen Charlotte subspecies in its entirety as either "critically imperiled globally" or "imperiled globally" (West 1993).

Because less than 1,250 pairs of Queen Charlotte goshawks exist in southeast Alaska (estimate is 100-200 pairs) and they may be relatively discrete from those in British Columbia (see Distribution and Population Status), and if their habitat capability has been declining by 10% per generation (see above and also see section on Population Density and Trends), then goshawks in southeast Alaska meet Mace and Lande's (1991) criteria for "endangered". Indeed, if the southeast Alaska population is below 125 pairs, then that by itself would be adequate criterion for being "endangered" (Mace and Lande 1991).

CONSERVATION STRATEGY

Early habitat recommendations for A. g. atricapillus concentrated on protecting existing nesting stands and developing future nest stands (Jones 1981, Reynolds et al. 1982, Reynolds 1983, Bloom et al. 1985, Crocker-Bedford 1987, Crocker-Bedford and Chaney 1988, Fowler 1988, Kennedy 1988, Woodbridge 1988, McCarthy et al. 1989), though foraging habitat beyond the nest stand was considered to some extent (Jones 1981, Reynolds 1983, Fowler 1988, Kennedy 1988, McCarthy et al. 1989). As the importance of foraging habitat beyond the nest stand became better documented, habitat strategies considered concentrated use areas beyond the nest stand (Kennedy 1989, USDA Forest Service 1991b, Hargis et al. 1993). Most recent strategies for A. g. atricapillus consider entire home ranges or even entire landscapes (Crocker-Bedford 1990b, Warren et al. 1990, Reynolds et al. 1992, AG&F 1993, Austin 1993, Mannan and Smith 1993). Marshall (1992) reviewed the history and variety of habitat management strategies.

Owing to its restricted geographical distribution and larger home ranges, the international population of Queen Charlotte goshawks is much lower than that of A. g. atricapillus. The precarious status of the Queen Charlotte goshawk (see section on Viability and Distribution Concerns) implies that it should receive more conservative management than recommended by authors in the previous paragraph for the more abundant atricapillus subspecies. In southern southeast Alaska Queen Charlotte pairs have exhibited extraordinarily huge home ranges, which implies that the population there is more imperiled than that in northern southeast Alaska. To maintain the viability and distribution of the Queen Charlotte goshawk on the Tongass National Forest of southeast Alaska, as required by the regulations of the National Forest Management Act, will require a concerted effort to maintain the key habitats of every existing home range. Apparently suitable home ranges without known occupancy may also need to be carefully managed. The following conservation strategy improves, for goshawks, upon those previously recommended to maintain viability and distribution of birds and mammals in southeast Alaska (Crocker-Bedford et al. 1991, Suring et al. 1993).

HCA's and Other Large Protected Areas

Congressional set-asides such as Wilderness Areas, Forest Service deferrals such as Primitive Recreation Areas (USDA Forest Service 1991a), and (if approved) old-growth Habitat Conservation Areas or HCA's (Crocker-Bedford et al. 1991, Suring et al. 1993), all potentially benefit the Queen Charlotte goshawk. Protected areas provide tracts where nesting and foraging habitat will be preserved, to the extent they are present, without additional management. Goshawk habitat there will be protected without expensive (Joy et al. 1993) and often inconclusive (Kimmel and Yahner 1990, Kennedy and Stahlecker 1993) nesting surveys. Furthermore, foraging habitat in protected areas will not require speculative analyses---home range specific management plans outside protected areas are unlikely to fully anticipate all the key foraging stands needed by goshawks. Obviously more Congressional set-asides, Forest Service deferrals, and old-growth HCA's reduce risks to the viability and distribution of the Queen Charlotte goshawk; however, protected areas by themselves are unlikely to encompass enough home ranges to assure viability and adequate distribution of the subspecies.

Individual Home Ranges Outside Protected Areas

Several alternatives exist for habitat management, ranging from the most conservative with the least risk to viability and distribution, to the least conservative with more risk to viability and distribution of the Queen Charlotte goshawk. The alternative chosen by the Forest Service will obviously have implications for the management of other resources.

Most of the alternatives below could be applied to up to four probabilities of home ranges: (1) definite breeding ranges around confirmed nest sites, where goshawks have actually been seen on or near occupied nests, or where goshawk feathers have been found below nests characteristic of goshawks; (2) probable breeding home ranges, where adult goshawks have been observed in courtship displays, in defensive actions (stooping), or giving defensive or territorial vocalizations (kak kak), or where fledglings (less than 30 days out of nest) have been observed; (3) possible breeding home ranges, where goshawks or probable goshawks have been observed during the nesting season; and (4) apparently suitable breeding home ranges without known occupancy anytime in past. The definition of "apparently suitable breeding home range without known occupancy" could vary widely, and therefore would have very different effects according to the definition that is eventually selected. It would be logical to apply more conservative management to definite and probable home ranges, less conservative management to possible home ranges, and even less conservative management to apparently suitable home ranges for which past occupancy is not known.

Whenever radio-telemetry data are available, they should be used to help delineate a home range, or to redefine a home range previously delineated without such data. Obviously more relocation points over more seasons and years allow a more accurate analysis of a home range. A prediction of a home range based on data from other pairs of goshawks, even if from the same portion of southeast Alaska, is unlikely to be fully accurate. The level of inaccuracy could negatively affect the success of the goshawk habitat management, as well as adversely affect timber harvesting in locations that are not important to goshawks. Kenward (1993) found that radio-telemetry efforts are inexpensive relative to the data provided, but that radiotagging can occasionally affect goshawk behavior and survival.

When actual relocation points are known for a pair, I advise against using a mean-harmonic home range, or a calculated non-circular home range, in a management analysis. Such mathematically generated home ranges tend to change the shape of home ranges in manners that drop important habitats and add unused habitats (Stahlecker and Smith 1993).

The most conservative (lowest risk to goshawks) management would protect all old-growth over the entire, year-long home range of each pair of adults. ADF&G (1994) showed that 92% of 667 locations in southeast Alaska were in old-growth having over 8 mbf/ac.

A slightly less conservative, but still low risk, management standard would protect all old-growth in the breeding home range---the area used from courtship until dispersal (dispersal dates differ for different ages and sexes). Within the year-long home range of the adults but outside the breeding home range, only stands that average over 20 mbf/ac would be protected. Old-growth over 20 mbf/ac is more preferred and more used than old-growth of 8-20 mbf/ac (ADF&G 1993a, 1994, and see section on Habitat Structure and Composition).

Widen (1989) found that mature forest in patches larger than 100 ac was 10 times more preferred, on a per acre basis, than mature forest in patches under 50 ac. The assumption that his Swedish results apply to southeast Alaska leads to a still less conservative (more risk) management option. Within the breeding home range, the option would protect all old-growth over 8 mbf/ac that is in patches over 100 ac, as well as all nesting stands. Within the year-long home range but outside the breeding home range, the option would protect patches larger than 100 ac that average over 20 mbf/ac.

A still less conservative and higher risk, management option would protect within the year-long home range all patches of forest larger than 100 ac that average over 20 mbf/ac. It would also protect all nesting stands.

The least conservative and highest risk management option, which I believe might still be compatible with law, would protect within the breeding home range all patches of forest larger than 100 ac that average over 20 mbf/ac. All nesting stands would also be protected.

Still another strategy would be the same as the previous one, except it would be applied only to an area equivalent in size to the 75% mean-harmonic home range of the pair during the breeding season. More research (see Research Recommendations) may provide knowledge for a system which sufficiently protects viability with less impacts on timber harvest.

If extensive radio-telemetry data have been gathered on a pair of birds---perhaps over 200 relocations over two years---then they could be used to develop a management plan specific to that home range. Such a plan could be more accurate in protecting key stands and important habitats within that specific home range, while at the same time freeing more timber stands for harvest.

The above recommendations are based on reports and literature as of February 1994, and could change as more is learned about goshawks, especially about Queen Charlotte goshawks. I recommend avoiding significant amounts of experimental silviculture in important habitats within definite, probable and possible home ranges; however, small amounts of experimental techniques could be useful, if they were carefully monitored to discern whether goshawk use of the treated stands increased or decreased. In locales without any evidence of past goshawk occupancy, wide-scale silvicultural experiments could be tried in an effort to develop better habitat that would induce goshawks to take up residence. Such experiments would probably include thinning from below (Crocker-Bedford 1990b).

Surveys to Locate Nesting Stands

The characteristics of nesting stands have been well described and are relatively uniform across the entire range of northern goshawks in North America. Nest stands almost always have trees large enough to easily support a goshawk nest (large limbs or crotches) and permit flight beneath the canopy. Nest stands usually have sparser brush, understory and mid-story canopies (relative to most other stands in a vicinity), and this may improve goshawk flight space beneath the overstory. Nest trees tend to occur on gentle slopes, usually under 30% and always under 60%. Nest trees tend to occur near the toe of a slope or on a somewhat flatter bench on a longer slope. Nest stands have dense overstory canopies, perhaps for improved microclimate or to reduce competition and predation by other raptors. (Most of the above was stated by each of Bartelt 1977, Hennessy 1978, Shuster 1980, Jones 1981, Reynolds et al.

1982, Saunders 1982, Moore and Henny 1983, Reynolds 1983, Hall 1984, Bloom et al. 1985, Erickson 1987, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988, Fowler 1988, Kennedy 1988, Hayward and Escano 1989, Reynolds 1989, Falk 1990, Patla 1990, Warren et al. 1990, Kimmel and Yahner 1992, Marshall 1992).

After collecting new data and reviewing the literature, Crocker-Bedford and Chaney (1988) suggested that the primary importance of stand aspect, in regards to nesting, is aspect's influence on stand structure (tree size, density of overstory, openness of understory). In southeast Alaska goshawk nest stands have been recorded for every aspect except northwest (ADF&G 1994). I suspect with more sampling nests will be found there, too.

Goshawks nest in stands larger than 20 acres (Reynolds 1983), but are more likely to reoccupy nest stands larger than 150 acres (Woodbridge 1988, Woodbridge and Detrich 1993). Nesting may be affected by the foraging habitat and forest composition beyond the nesting stand (see section on Habitat Structure and Composition).

Typically 3 alternate nests are used in a territory in different years, though a territory may contain up to 5 alternate nests (Crocker-Bedford 1990b). In Oregon nests were typically 200-300 feet apart (Reynolds and Wight 1978). In California the median distance between alternate nests of consecutive years was 770 feet while the mean distance was 2,000 feet, and one movement was 1.7 miles (Woodbridge 1988). In northern Arizona most alternate nests were closer than 1,000 feet (Crocker-Bedford 1990b).

Even when nest sites are actually occupied, they may go undetected during surveys using taped broadcasts of conspecific calls (Kimmel and Yahner 1990, Kennedy and Stahlecker 1993). Goshawks usually do not respond while incubating eggs, and response rates vary somewhat between the periods of courtship, nestlings, and fledgling-dependency (Kennedy and Stahlecker 1993). Still, the three responsive periods averaged a rate of detection (effectiveness) of about 75% when the observer was within 100 m (8 ac) of the nest, about 50% effectiveness when 100-200 m (a 23-ac ring) from the nest, and about 20% effectiveness when 200-300 m (a 39-ac ring) from the nest. The summation of these effectiveness rates and ring sizes gives an equivalency of 100% effectiveness for 25 ac., assuming the nest site is occupied during the season of survey.

Within the goshawk analysis area for each project which could potentially adversely affect goshawks, survey effort should vary according to the potential of a location to contain a goshawk nest. In Arizona Crocker-Bedford and Chaney (1988) found that nest stands were typically denser than 90% of the other mature stands within 1 km. This is less likely to be the case in southeast Alaska, where so many stands are at least as dense and tall as those used elsewhere for nesting. Even so, the Arizona study provides some logic to survey in three different years (recall that 3 alternate nests are typical) the 10% of the productive forest (>8 mbf/ac) which appears most likely to contain a nest. This would provide the potential to discover most of the nests of the apparently highest quality nesting habitats.

The 20% of the productive forest (>8 mbf/ac) next most likely to contain a nest should be surveyed twice over two years. This would provide the potential to discover half the alternate nests which exist within habitat of that apparent quality.

The 20% of the productive forest (>8 mbf/ac) next most likely to contain a nest should be surveyed at least once. This would provide the potential to discover any nest that happened to be occupied there that same year.

I assume biologists understand goshawks well enough to accurately estimate the 50% of the productive forest which is least likely to include a goshawk nest. Surveys are not recommended there.

Breeding surveys should also emphasize areas where goshawks have been observed, especially areas with repeated observations between March and early August.

Landscape Management Through a Long Timber Rotation

A very different, managed landscape approach would place the entire suitable and available timber base of the Tongass NF on a 200-year timber rotation. Only 5% of the suitable and available timber base of an assessment area would be regenerated in any one decade. The concept is based on assumptions that in southeast Alaska sufficient goshawk flight space and prey are available in stands 100-200 years old. A major advantage of this system is that little potentially suitable goshawk habitat would receive timber harvesting before wildlife could be better studied. Also, goshawk protection would not depend upon expensive, incomplete, and unreliable nesting surveys. The timber harvest level would be affected in the short-term, but timber quality over the long-term would be much higher and more competitive (P. Alaback pers. comm.). A timber rotation of at least 200 years would adequately protect existing habitat while allowing degraded habitat to recover over the long-term for goshawks (Crocker-Bedford 1990b, Reynolds et al. 1992).

Between large permanently protected areas (Wildernesses, Primitive Recreation Areas, large and medium HCA's, etc.), the forest matrix could be partitioned into three 2,500-5,000 ac tracts per watershed (Crocker-Bedford 1990b), perhaps 3 tracts per Tongass NF Value Comparison Unit. The 3 matrix tracts might surround a small permanent no-harvest area (Crocker-Bedford 1990b), perhaps the small HCA (>1,600 ac) of Suring et al. (1993). During the first 70 years of the long timber rotation, regeneration harvesting would be concentrated in 1 matrix tract and would avoid the other 2 tracts. Over the next 70 of the 200+ years, the second matrix tract would be regenerated, and over the final 70 years the third tract would be regenerated. The size of the harvest units within the tract being regenerated might not matter much to goshawks, but smaller regeneration patches would more closely mimic the natural forest.

Such a system would provide tracts of unfragmented mid-aged (70-140 years) and mature forest (140-210 years), while limiting the amount of area in fragmented and young forest as recommended by Crocker-Bedford (1990b). Recall that Widen (1989) determined that goshawks preferred mature forest in tracts over 100 ac 10 times more, on a per acre basis, than tracts smaller than 50 ac.

RESEARCH RECOMMENDATIONS

ADF&G (1993a, 1994) determined that 92% of the relocations of Queen Charlotte goshawks occurred in old-growth stands having over 8 mbf/ac, and that stands having over 20 mbf/ac were more preferred. For each volume class (8-20 mbf/ac and >20 mbf/ac), I recommend visiting a random sample of stands known to have been used 2 or more times, as well as stands not known to have been used (I recognized wider standard error because some not known to have been used really would have been). Data would be gathered to estimate why some stands of 8-20 mbf/ac are used while most such stands are not known to be used, and to estimate why many stands with over 20 mbf/ac are used while others are not known to be used. Forest structure and plant composition would be assessed, as would relative prey densities. Prey densities should be assessed in the same month as the stands are used. In addition, the geographic information system (GIS) should be used to assess patch size, elevation, aspect, and proximity to the nest for all stands having radio relocations, as well as a sample of stands without relocations. Such information would enable refinement of which stands should be managed for goshawks and which should emphasize other resources.

Study should continue to assess home range sizes and the reasons that they differ. Study should assess why breeding densities apparently differ in different portions of southeast Alaska.

Survival rates should be assessed through radiotelemetry (Kenward 1993).

Determine dispersal distances.

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LITERATURE CITED

ADF&G. 1978. Alaska's wildlife and habitat, Vol II. Alaska Dept. Fish and Game, Juneau.

______. 1993a. A summary of survey, radio-telemetry, and other results regarding goshawk field studies in southeast Alaska. Ketchikan Forest Raptor Study Final Report, Alaska Dept. of Fish and Game Division of Wildlife Conservation. 36pp.

______. 1993b. Goshawk ecology and habitat relationships on the Tongass National Forest---1993 field season progress report. USDA For. Serv. Contract No. 43-0109-3-0272. Alaska Dept. of Fish and Game Division of Wildlife Conservation. 12 pp.

______. 1994. Goshawk ecology and habitat relationships on the Tongass National Forest---goshawk nest sites, food habits, morphometrics, and telemetry data progress report. Contract 43-0109-3-0272 with USDA Forest Service. Draft of February 1994 as modified by 20 April 1994.

AG&F. 1993. Review of U.S. Forest Service strategy for managing northern goshawk habitat in the southwestern United States. Arizona Game and Fish Department, Phoenix. 87 pp. + appendices.

Allen, B. A. 1978. Nesting ecology of the goshawk in the Adirondacks. M.S. Thesis, State Univ. of New York, Syracuse. 71 pp.

Armstrong, R. H. 1990. Guide to the birds of Alaska, third edition. Alaska Northwest Books, Bothell, Wash. 342 pp.

Austin, K. F. 1993. Habitat use and home range size of breeding goshawks in the southern Cascades. M.S. Thesis, Oregon State Univ., Corvallis, Oregon. 63 pp.

Bartelt, P. E. 1977. Management of the American goshawk in the Black Hills National Forest. M.S. Thesis, Univ. South Dakota, Vermillion. 102pp.

Beebe, F. L. 1974. Field studies of the Falconiformes of British Columbia. B. C. Prov. Mus. Occas. Pap. Ser. 17.

Bent, A. C. 1937. Life histories of North American birds of prey, part 1. Dover Publ., New York. 409pp.

Bloom, P. H., G. R. Stewart, and B. J. Walton. 1985. The status of the northern goshawk in California, 1981-1983. Calif. Dep. Fish and Game, Wildl. Manage. Branch Adm. Rep. 85-1. 26pp.

Boyce, D. A., R. T. Reynolds, M. Kirkeminde, and J. R. Ellenwood. 1993. Goshawk reproduction and forest management in northern Arizona: a reanalysis. Abstract for annual meeting of Raptor Res. Foundation. Nov. 1993 at Charlotte, N. Carolina.

Brown, L., and D. Amadon. 1968. Eagles, hawks and falcons of the world, Vol. 2. Hamlyn Publ. Group Limited, New York. 944pp.

Campbell, R. W., N. K. Dawe, I. McTaggart-Cowan, J. M. Cooper, G. W. Kaiser, and M. C. E. McNall. 1989. The birds of British Columbia. Royal British Columbia Museum, Victoria, BC. 1,000 pp.

Crocker-Bedford. D. C. 1987. Monitoring the effectiveness of buffers for goshawk nests. Southwest Habitater, Feb. 1987:1-2.

______. 1990a. Status of the Queen Charlotte goshawk. U.S. Dep. Agric., For. Serv., Tongass Natl. For., Ketchikan, Alas. 16pp.

______. 1990b. Goshawk reproduction and forest management. Wildl. Soc. Bull. 18:262-269.

______. 1991. Goshawk reproduction at different levels of timber harvest Annu. Meeting Soc. Conserv. Biol. Abstracts 5:208.

______. 1993. A conservation strategy for the Queen Charlotte goshawk on the Tongass National Forest (17 April 1992 version). Pages 113-143 in Suring et al. 1993. A proposed strategy for maintaining well-distributed, viable populations of wildlife associated with old-growth forests in Southeast Alaska. Unpubl. Rep. USFS/ADF&G/USFWS Interagency Committee, Juneau, Alaska. 278 pp.

______, and B. Chaney. 1988. Characteristics of goshawk nesting stands. Pages 210-217 in R.L. Glinski, B.G. Pendleton, M.B. Moss, M.N. LeFranc, Jr., B.A. Millsap, and S.W. Hoffman, eds. Proc. Southwest raptor management symposium and workshop. Natl. Wildl. Fed. Sci. and Tech. Ser. 11.

______, R. Flynn, C. Iverson, M. Kirchhoff, F. Samson, T. Schenck, L. Shea L. Suring, and K. Titus. 1991. Recommended standards for maintaining well distributed, viable populations of species associated with old-growth forest habitats. Report (2620) of 12 February to the IDT Leader for Tongass Land Management Planning.

Detrich, P. and B. Woodbridge. 1993. Territory fidelity, mate fidelity and movements of colormarked northern goshawks in the southern Cascades of California. Abstract in Northern Goshawk Symposium. Sacramento, CA.

Doyle, F. I., and J. N. M. Smith. 1993. Responses of northern goshawks to a peak and decline in snowshoe hare numbers. Abstract for Northern Goshawk Symposium, Sacramento, Calif.

Erickson, M. G. 1987. Nest site habitat selection of the goshawk (Accipiter gentilis) in the Black Hills National Forest of South Dakota. M.S. Thesis, Univ. of South Dakota. 49 pp.

Falk, J. 1990. Landscape level raptor habitat associations in northwest Connecticut. M.S. Thesis, Virginia Polytechnic Inst. and State Univ., Blacksburg. 118pp.

Federal Government of Canada. 1991. The state of Canada's environment. Government of Canada, Ottawa.

Fisher, D. L. 1986. Daily activity patterns and habitat use of coexisting Accipiter hawks in Utah. Ph.D. Thesis, Brigham Young Univ., Provo, Ut.

______, and J. R. Murphy. 1986. Foraging and nesting habitat of Accipiter hawks in Utah. Unpublished manuscrip. Dept. of Biology, Brigham Young University.

Forsman, E. 1994. Tongass National Forest Land Management Plan Scientific Review. Pages 43-48 in A. R. Kiester and C. Eckhardt, Review of wildlife management and conservation biology on the Tongass National Forest: a synthesis with recommendations. For. Ser. Pacific Northwest Research Station, Corvallis, Oregon. 282 pp.

Fowler, C. 1988. Habitat capability model for the northern goshawk. U.S. Dep. Agric., For. Serv., Pac. Southwest Reg., San Francisco, Calif. 21pp.

Frost, E., and M. Friedman. 1992. B.C. forests: public land, corporate control. Northwest Conservation News and Priorities. Greater Ecosystem Alliance, Bellingham, WA.

Fuller, M. A., and J. A. Mosher. 1987. Raptor survey techniques. Pages 37-65 in B. Grion Pendleton, B.A. Millsap, K.W. Cline, and D.M. Bird, eds. Raptor management techniques manual. Natl. Wildl. Fed., Wash., D.C.

Gamauf, A. 1988. Hierarchial order in choice of nest sites and hunting habits of three sympatric raptor species (Buteo buteo, Pernis apivorus, and Accipiter gentilis) Ph.D. Dissertation zur Erlangung des. Doktorgrades an der Formal---und Naturwissenschaft lichen Fakultat der Universitat Wien. 105 pp.

Glutz v. Blotzheim, U., K. Bauer, and E. Bezzel. 1971. Handbuch der Vogel Mitteleuropas. Band 4 (Falconiformes). Akademische Verlagsgesellschaft, Frankfurt am Main.

Gullion, G. W. 1990. Ruffed grouse use of conifer plantations. Wildl. Soc. Bull. 18:183-187.

Gustafson, J. 1991. Ketchikan Area raptor survey 1991, progress report #1 for Sike's Act Contract 43-0109-1-0323 between Tongass NF and Alaska Dept. Fish and Game. 9pp plus appendices.

Hall, P. A. 1984. Characterization of nesting habitat of goshawks (Accipiter gentilis) in northwestern California. M.S. Thesis, California State Univ., Humboldt. 70pp.

Hargis, C. D., C. McCarthy, and R. D. Perloff. 1993. Home ranges and habitats of northern goshawks in eastern California. Abstracts of Northern Goshawk Symposium, April 1993, Sacramental, Calif.

Hayward, G. D., and R. E. Escano. 1989. Goshawk nest-site characteristics in western Montana and northern Idaho. Condor 91:476-479.

Hennessy, S. P. 1978. Ecological relationships of accipiters in northern Utah---with special emphasis on the effects of human disturbance. M.S. Thesis, Utah State Univ., Logan. 66pp.

Herron, G. B., C. A. Mortimore, and M. S. Rawlings. 1985. Nevada raptors, their biology and management. Nev. Dep. Wildl. Biol. Bull. 8. 114pp.

Heslin, B. S,, J. T. Driscoll, and L. Z. Ward. 1993. 1992 Northern goshawk nesting survey on the Kaibab Plateau, Arizona. Nongame and Endangered Wildlife Program Technical Report, Arizona Game and Fish Department, Pheonix, Arizona. 77pp.

Hoglund, N. 1964. Der Habicht Accipiter gentilis Linne in Fennoscandia. Beringungsergebnisse und Okologische Studien. Viltrevy 2:195-270.

Johnsgard, P. A. 1990. Hawks, eagles and falcons of North America: biology and natural history. Smithsonian Inst. Press, Wash., D.C. 403pp.

Johnson, D. R. 1989. Body size of northern goshawks on coastal islands of British Columbia. Wilson Bull. 101(4):637-639.

Jones, S. 1981. The Accipiters---goshawk, Cooper's hawk, sharp-shinned hawk. U.S. Dep. Inter., Bur. Land Manage. Tech. Note 335. 51pp.

Joy, S. M., R. T. Reynolds, and D. G. Leslie. 1993. Northern goshawk broadcast surveys: hawk response variables and survey costs. Abstract of Northern Goshawk Symposium, Sacramento, Calif.

Kennedy, P. L. 1988. Habitat characteristics of cooper's hawks and northern goshawks nesting in New Mexico. Pages 218-227 in R. L. Glinski, B.G. Pendleton, M.B. Moss, M.N. LeFranc, Jr., B.A. Millsap, and S.W. Hoffman, eds. Proc. Southwest raptor management symposium and workshop. Natl. Wildl. Fed. Sci. and Tech. Ser. 11.

_____. 1989. The nesting ecology of Cooper's hawks and northern goshawks in the Jemez Mountains, NM---a summary of results, 1984-1988. U.S. Dep. Agric., For. Ser., Final Rep. Contract P.O.# 43-8379-8-346. 21pp.

_____. 1990. Reproductive strategies of northern goshawks and Cooper's hawks in north-central New Mexico. Ph.D. dissertation, Utah State Univ., Logan, Utah. 224 pp.

_____, and D. W. Stahlecker. 1993. Responsiveness of nesting northern goshawks to taped broadcasts of 3 conspecific calls. J. Wildl. Manage. 57:249-257.

Kenward, R. E. 1982. Goshawk hunting behaviour, and range size as a function of food and habitat availability. J. Anim. Ecol. 51:69-80.

_____. 1993. Modelling raptor populations: to ring or radio-tag? Pages 157-167 in J. D. Lebreton and P. M. North (eds), Marked Individuals in the Study of Bird Populations. Birkhauser Verlag, Basel, Switzerland.

_____, V. Marcstrom, and M. Karlbom. 1991. The goshawk (Accipiter gentilis) as predator and renewable resource. Gibier Faune Sauvage 8:367-378.

_____, _____, _____. 1993a. Post-nestling behavior in goshawks, Accipiter gentilis: I. The causes of dispersal. Anim. Behav. 46:365-370.

_____, _____, and _____. 1993b. Post-nestling behavior in goshawks, Accipiter gentilis: II. Sex differences in sociality and nest-switching. Anim. Behav. 46:371-378.

Kenward, R. E., and P. Widen. 1989. Do goshawks Accipiter gentilis need forests? Some conservation lessons from radio tracking. pp. 561-567 in B.-U. Meyburg and R. D. Chancellor (eds.), Raptors in the Modern World. WWGBP London.

Kiester, A. R., and C. Eckhardt. 1994. Review of wildlife management and conservation biology on the Tongass National Forest: a synthesis with recommendations. For. Ser. Pacific Northwest Research Station, Corvallis, Oregon. 282 pp.

Kimmel, J. T., and R. H. Yahner. 1990. Response of northern goshawks to taped conspecific and great horned owl calls. J. Raptor Res. 24:107-112.

_____ and _____. 1992. Landscape analysis of northern goshawk habitat in two forest regions of Pennsylvania. Abstract of Raptor Research Foundation Annual Meeting, Bellevue, WA.

Kostrzewa, A. 1987. Quantitative untersuchungen zur habitattrennuing von Mausebussard (Buteo buteo), Habicht (Accipiter gentilis) and Wespenbussard (Pernis apivorus). J. Ornithol. 128:209-229.

Lande, R. 1987. Extinction thresholds in demographic models of territorial populations. Am. Nat. 130:624-635.

______. 1988. Genetics and demography in biological conservation. Science 241:1455-1460.

Mace, G. M., and R. Lande. 1991. Assessing extinction threats: toward a reevaluation of IUCN threatened species categories. Conserv. Biol. 5:148-157.

Mannan, R. W., and C. W. Boal. 1993. Diets of northern goshawks in ponderosa pine forests, northern Arizona. Final Report for Cost-Share Agreement between Kaibab National Forest and School of Renewable Natural Resources, Univ. Ariz., Tucson. 27 pp.

Mannan, R. W., and E. C. Meslow. 1984. Bird populations and vegetation characteristics in managed and old-growth forests, northeastern Oregon. J. Wildl. Manage. 48:1219-1238.

Mannan, R. W., and D. J. Smith. 1991. Habitat use by foraging goshawks on the Kaibab Plateau in northern Arizona. Interim report for US For. Serv. and Univ. Ariz. Coop. Agreement No. 28-C1-558. 22 pp.

______. 1993. Habitat use by breeding male northern goshawks in northern Arizona. Final report for US For. Serv. and Univ. Ariz. Coop. Agreement No. 28-C1-558. 36 pp.

Marshall, D. B. 1992. Status of the northern goshawk in Oregon and Washington. Audubon Soc. of Portland, Oreg. 35 pp.

McCarthy, C., W. D. Carrier, and W. F. Laudenslayer. 1989. Coordinating timber management activities with raptor nesting habitat requirements. Pages 229-235 in B.G. Pendleton, C.E. Ruibal, D.L. Krahe, K. Steenhof, M.N. Kochert, and M.N. LeFranc, Jr., eds. Proc. western raptor management symposium and workshop. Natl. Wildl. Fed. Sci. and Tech. Ser. 12.

McGowan, J. D. 1975. Distribution, density and productivity of goshawks in interior Alaska. Final Rep. Fed. Aid in Wildl. Restor. Proj. W-17-3,4,5,6, Alas. Dep. Fish and Game, Juneau. 57pp.

Moore, K. R., and C. J. Henny. 1983. Nest site characteristics of three coexisting accipiter hawks in northeastern Oregon. Raptor Res. 17:65-76.

______, and ______. 1984. Age-specific productivity and nest site characteristics of Cooper's hawks (Accipiter cooperii). Northwest Science 58:290-299.

Palmer, R. S. 1988. Handbook of North American Birds, Vol. 4. Yale Univ. Press, New Haven, Conn. 448pp.

Patla, S. 1990. Northern goshawk monitoring project report, 1989. U.S. Dep. Agric., Targhee Nat. For., Final Rep. Contract #43-02S2-8-1931. St. Anthony, Idaho. 37pp.

______. 1991. Northern goshawk monitoring report #2, 1990. U.S. Dep. Agric., Targhee Nat. For., Final Rep. Contract # 43-02S2-0-0184. St. Anthony, Idaho. 42pp.

Postupalsky, S. 1974. Raptor reproductive success: some problems with methods, criteria, and terminology. Pages 21-31 in F. N. Hamerstrom, Jr., B. E. Harrel, and R. R. Olendorff, eds. Management of raptors. Raptor Res. Found., Vermillion, S.D.

______. 1975. Current status of some Michigan raptors. Jack-pine Warbler 53:76-77.

Reed, J. M., P. D. Doerr, and J. R. Walters. 1986. Determining minimum population sizes for birds and mammals. Wildl. Soc. Bull. 14:255-261.

Reynolds, R. T. 1983. Management of western coniferous forest habitat for nesting accipiter hawks. U.S. Dep. Agric., For. Serv. Gen. Tech. Rep. RM-102. 7pp.

_____. 1989. Accipiters. Pages 92-101 in B. G. Pendleton, C.E. Ruibal, D.L. Krahe, K. Steenhof, M.N. Kochert, and M.N. LeFranc, Jr., eds. Proc. western raptor management symposium and workshop. Natl. Wildl. Fed. Sci. and Tech. Ser. 12.

_____, R. T. Graham, M. H. Reiser, R. L. Bassett, P. L. Kennedy, D. A. Boyce, G. Goodwin, R. Smith, and E. L. Fisher. 1992. Management recommendations for the northern goshawk in the southwestern United States. Gen. Tech. Rep. RM-217. USDA For. Serv., Rocky mtn. For. and Range Exp. Sta., Ft Collins, CO. 90 pp.

_____, and E. C. Meslow. 1984. Partitioning of food and niche characteristics of coexisting Accipiter during breeding. Auk 101:761-779.

_____, and H. M. Wight. 1978. Distribution, density, and productivity of Accipiter hawks breeding in Oregon. Wilson Bull. 90:182-196.

_____, E. C. Meslow, and H. M. Wight. 1982. Nesting habitat of coexisting Accipiter in Oregon. J. Wildl. Manage. 46:124-138.

Saunders, L. B. 1982. Essential nesting habitat of the goshawk (Accipiter gentilis) on the Shasta-Trinity National Forest, McCloud District. M.S. Thesis, California State Univ., Chico. 57pp.

Schnell, J. H. 1958. Nesting behavior and food habits of goshawks in the Sierra Nevada of California. Condor 60:377-403.

Shuster, W. C. 1976. Northern goshawk nesting densities in montane Colorado. Western Birds 7:108-110.

_____. 1980. Northern goshawk nest site requirements in the Colorado Rockies. West. Birds 11:89-96.

Sidle, W. B., and L. H. Suring. 1986. Management indicator species for the National Forest Lands in Alaska. Wildlife and Fisheries Habitat Management Notes No. 10. Forest Service Alaska Region Tech. Pub. R10-TP-2. 62pp.

Speiser, R., and T. Bosakowski. 1987. Nest site selection by northern goshawks in northern New Jersey and southeastern New York. Condor 89:387-394.

Stahlecker, D. W., and T. G. Smith. 1993. A comparison of home range estimates for a bald eagle wintering in New Mexico. J. Raptor Res. 27:42-45.

Storer, R. W. 1966. Sexual dimorphism and food habits in three north American accipiters. Auk 83:423-436.

Suring, L. H., D. C. Crocker-Bedford, R. W. Flynn, C. Hale, G. C. Iverson, M. D. Kirchhoff, T. E. Schenck, L. C. Shea, and K. Titus. 1993. A proposed strategy for maintaining well-distributed, viable populations of wildlife associated with old-growth forests in Southeast Alaska. Unpublish. Rep. USFS/ADF&G/USFWS Interagency Committee, Juneau, Alaska. 278 pp.

Suring, L. H. and N. Pardew. 1993. List of neotropical migrant birds on National Forest in Alaska. Habitat Hotline 93-1. USDA For. Serv., Alaska Region, Juneau. 5 pp.

Swem, T., and M. Adams. 1992. A northern goshawk nest in the tundra biome. J. Raptor Res. 26:102.

Taverner, P. A. 1940. Variation in the American goshawk. Condor 42:157-160.

Thomas, C. D. 1990. What do real population dynamics tell us about minimum viable population sizes? Conserv. Biol. 4:324-327.

Thomas, J. W., E. D. Forsman, J. B. Lint, E. C. Meslow, B. R. Noon, and J. Verner. 1990. A conservation strategy for the northern spotted owl. U.S. Gov. Printing Off. 1990-791-171/20026. 427pp.

Thomas, J. W., M. G. Raphael, R. G. Anthony, E. D. Forsman, A. G. Gunderson, R. S. Holthausen, B. G. Marcot, G. H. Reeves, J. R. Sedell, and D. M. Solis. 1993. Viability assessment and management considerations for species associated with late-successional and old-growth forests of the Pacific Northwest. USDA For. Serv. 530 pp.

USDA Forest Service. 1991a. Tongass land management plan revision, supplement to the draft environmental impact statement. For. Ser. Alaska Reg. Pub. R10-MB-149.

_____. 1991b. Management guidelines for the northern goshawk in the Southwestern Region. Federal Register 56(199):51672-51680.

USDI Fish and Wildlife Service. 1992. Notice of initiation of status review on the northern goshawk. Federal Register 57(4):544-546.

Ward, L. Z., D. K. Ward, and T. J. Tibbitts. 1992. Canopy density analysis at goshawk nesting territories on the North Kaibab Ranger District, Kaibab National Forest. Nongame and Endangered Wildlife Program, Ariz. Game and Fish Dept., Pheonix. 61 pp.

Warren, N., G. D. Hayward, T. Holland, R. Escano, D. C. Crocker-Bedford, T. Komberec, D. Sasse, Linda Saunders-Ogg, and B. Shuster. 1990. Goshawk habitat relationships. Pages 19-27 in N. M. Warren, ed., Old-growth habitats and associated wildlife species in the northern Rocky Mountains. U.S. Dep. Agric., For. Serv. North. Reg. R1-90-42, Missoula.

Webster, J. D. 1988. Some bird specimens from Sitka, Alaska. Murrelet 69:46-48.

West, E. W. 1993. Rare vertebrate species of the Chugach and Tongass National Forests, Alaska. Alaska Natural Heritage Program, Anchorage. 254 pp.

Whaley, W. H. and C. M. White. 1993. Trends in geographic variation of Cooper's hawk and northern goshawk in North America: A multivariate analysis. Unpublished report, Dept. of Zoology, Brigham Young University. 131pp.

Widen, P. 1984. Activity patterns and time-budget in the Goshawk Accipiter gentilis in a boreal forest area in Sweden. Ornis Fennica 61:109-112.

_____. 1985. Breeding and movements of goshawks in boreal forests in Sweden. Holarctic Ecol. 8:273-279.

_____. 1987. Goshawk predation during winter, spring and summer in a boreal forest of central Sweden. Hol. Ecol. 10:104-109.

-----. 1989. The hunting habitats of goshawks (Accipiter gentilis) in boreal forests of central Sweden. Ibis. 131:205-231.

Woodbridge, B. 1988. Territory fidelity and habitat use by nesting goshawks:implications for management. West. Sec. Wildl. Soc., 10-13 February 1988, Hilo, Haw. 22pp.

_____, and P. Detrich. 1993. Territory ocupancy, nest site movements and reproductive success of northern goshawks in the southern Cascades of California. Abstract for Northern Goshawk Symposium, Sacramento, Calif.

Woodbridge, B., T. Jimerson, and B. Devlin-Craig. 1993. Forest dynamics, silviculture and management of northern goshawk habitat in the major forest types of northern California. Abstract for the Northern Goshawk Symposium, Sacramento, Calif.

Younk, J. V. and M. J. Bechard. 1992. Possible food-related early breeding of two-year old northern goshawks in shrub-steppe habitats of northeastern Nevada. Abstract of Raptor Research Foundation Annual Meeting, Bellevue, WA.

Zinn, L. J., and T. J. Tibbitts. 1990. Goshawk nesting survey--1990--North Kaibab Ranger District, Kaibab National Forest, Arizona. Ariz. Game and Fish Dep., Phoenix. 36pp.

Table 1. Densities of pairs of breeding goshawks in western coniferous forests. The most comparable densities are those by the same author, though comparisons could also be made within the northern portion of the Southwest (northern Arizona and northern New Mexico) and within California.

Number of Pairs/ 10,000 ac land	Timber Harvest	Location	Source
0.1	Much	South Dakota	Bartelt 1977
0.4	Fragmented	California	Bloom et al. 1985
0.5[a]	30% Selected	N. Arizona	Crocker-Bedford 1990b
0.8	>50% 2nd growth	N. California	Austin 1993
0.8[b]	Much Selected	N. New Mexico	Kennedy 1989
0.8	Little logging, but much fire	Central Alaska	McGowan 1975
1.3	Limited	California	Bloom at al. 1985
1.5	Limited	Oregon	Reynolds and Wight 1978
3.0	Little	Colorado	Shuster 1976
4.4	Light salvage and selection	N. Arizona	Crocker-Bedford and Chaney 1988
9.0	None	N. Arizona	Crocker-Bedford 1990b

[a] And only 0.5 nestling per pair.

[b] Does not include the 25% of all territories where the female was unpaired. Unusually low reproduction even where paired.